Test your understanding 3 – Single product

If the margin of safety budgeted in period 3 is 21.015%,

So we can rearrange the formula:

$$\text{Margin of safety (\%)} = \frac{\text{Budgeted sales} - \text{Breakeven sales}}{\text{Budgeted sales}} \times 100$$

To:

Breakeven Sales

= Budgeted Sales – (Budgeted Sales × Margins of Safety (%))

So the breakeven number of units in the period is:

6,570 – (6,570 × 21.015%) = 5,189 units

At the breakeven point, contribution is equal to the level of fixed costs.

Contribution at this volume is:

Sales units × Contribution per unit

= Sales Units × (C/S ratio × Sales Price)

= 5,189 × 35% × $72

= $130,763.

So fixed costs are $130,763.

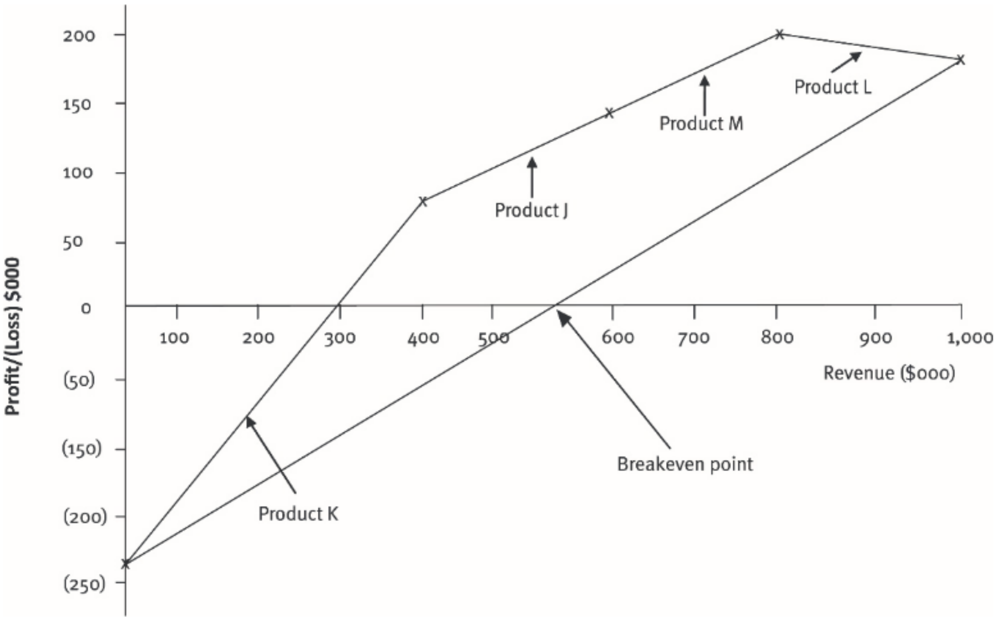
Test your understanding 4

(a)

Product	Revenue, in	Variable costs	Contribution	C/S ratio
	$000	$000	$000	
J	200	140	60	0.30
K	400	80	320	0.80
L	200	210	(10)	(0.05)
M	200	140	60	0.30
	1,000	**570**	**430**	

(b)

Product	Contribution, in	Cumulative Profit/(Loss)	Revenue	Cumulative revenue
	$000		$000	
		(240)		0
K	320	80	400	400
J	60	140	200	600
M	60	200	200	800
L	(10)	190	200	1,000



(c) The products are plotted in the order of their C/S ratios. The fixed costs of the company are $240,000. The chart reveals that if only product K is produced, the company will generate a profit of $80,000. The profit of the company is maximised at $200,000. This is achieved by producing Products K, J and M only.

If all four products are produced then JK Ltd can expect a profit of $190,000 from sales revenue of $1,000,000. If all four products are sold in the budget sales mix then the company will break even when revenue reaches $558,140. This point has been indicated on the graph. This point can also be calculated. Thus:

Average contribution/sales ratio = 430/1,000 = 43%

$$\text{Break-even point} = \frac{\text{Fixed cost}}{\text{Average C/S ratio}}$$

$$\text{Break-even point} = \frac{\$240{,}000}{0.43} = \$558{,}140$$

(d) The overall C/S ratio could be improved by:

- Changing the product mix in favour of products with above average C/S ratios. In this example that would mean increasing production of Product K.
- Increasing sales revenue.
- Deleting product L.

Test your understanding 5

Product	Total contribution $	Total sales revenue $	C/S ratio
J	42,000	105,000	40%
K	157,500	315,000	50%
	199,500	420,000	

$$\text{C/S ratio of the mix} = \frac{\$199{,}500}{\$420{,}000} = 47.5\%$$

$$\text{Break-even point} = \frac{\$120{,}000}{47.5\%} = \$252{,}632$$

OR

$$\text{C/S ratio of the mix} = \frac{(1 \times 40\%) + (3 \times 50\%)}{1 + 3}$$

= 47.5%

$$\text{Break-even point} = \frac{\$120{,}000}{47.5\%}$$

= **$252,632**

Test your understanding 6

$$\text{Breakeven point in \$ } \frac{\text{Fixed cost}}{\text{C/S ratio of the mix}}$$

C/S ratio of the mix = (0.3 × 27%) + (0.2 × 56%) + (0.5 × 38%) = 38.3%

$$\text{Therefore, BEP } \frac{\$648{,}000}{38.3\%}$$

= $1,691,906

Chapter

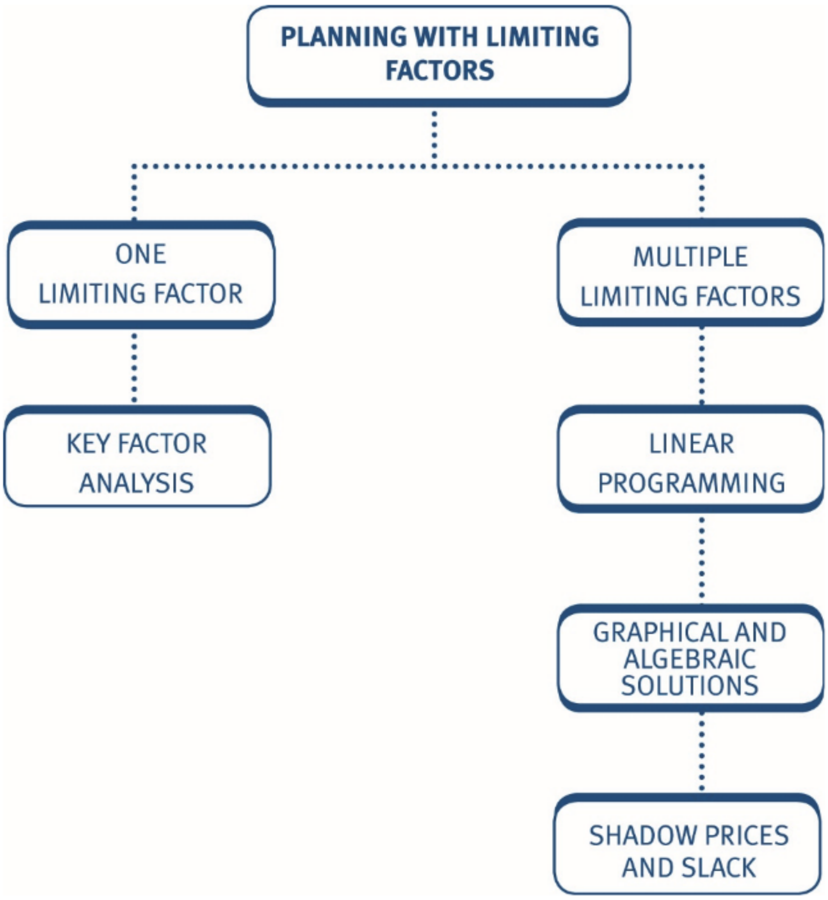
6

Planning with limiting factors

Chapter learning objectives

Upon completion of this chapter you will be able to:

- Identify limiting factors in a scarce resource situation and select an appropriate technique.
- Determine the optimal production plan where an organisation is restricted by a single limiting factor, including within the context of make-or-buy decisions.
- Formulate and solve multiple scarce resource problems using both linear programming graphs and using simultaneous equations as appropriate.
- Explain and calculate shadow prices (dual prices) and discuss their implications for decision-making and performance management.
- Calculate slack and explain the implications of the existence of slack for decision-making and performance management. (Excluding simplex and sensitivity to changes in objective functions.)


PLANNING WITH LIMITING FACTORS
ONE LIMITING FACTOR
MULTIPLE LIMITING FACTORS
KEY FACTOR ANALYSIS
LINEAR PROGRAMMING
GRAPHICAL AND ALGEBRAIC SOLUTIONS
SHADOW PRICES AND SLACK

1 Introduction

Firms face many constraints on their activity and plan accordingly:

- limited demand
- limited skilled labour and other production resources
- limited finance ('capital rationing').

Examination questions will focus on the problem of scarce resources that prevent the normal plan being achieved.

For example, a firm is facing a labour shortage this month due to sickness and, as a result, cannot produce the number of units that it would like to. How should its production plan be revised?

2 Planning with one limiting factor

The usual objective in questions is to maximise profit. Given that fixed costs are unaffected by the production decision in the short run, the approach should be to maximise the contribution earned. We have covered a similar approach in Chapter 4, with Throughput Accounting.

If there is one limiting factor, then the problem is best solved using key factor analysis:

Step 1: identify the scarce resource.

Step 2: calculate the contribution per unit for each product.

Step 3: calculate the contribution per unit of the scarce resource for each product.

Step 4: rank the products in order of the contribution per unit of the scarce resource.

Step 5: allocate resources using this ranking and answer the question.

Test your understanding 1

X Ltd makes three products, A, B and C, for which unit costs, machine hours and selling prices are as follows:

	Product A	**Product B**	**Product C**
Machine hours	10	12	14
	$	$	$
Direct materials @ 50c per kg	7 (14 kg)	6 (12 kg)	5 (10 kg)
Direct wages @ $7.50 per hour	9 (1.2 hours)	6 (0.8 hours)	3 (0.4 hours)
Variable overheads	3	3	3
Marginal cost	19	15	11
Selling price	25	20	15
Contribution	6	5	4

Sales demand for the period is limited as follows.

Product A	4,000
Product B	6,000
Product C	6,000

Company policy is to produce a minimum of 1,000 units of Product A.

The supply of materials in the period is unlimited, but machine hours are limited to 200,000 and direct labour hours to 5,000.

Required:

Indicate the production levels that should be adopted for the three products in order to maximise profitability, and state the maximum contribution.

The value of additional resources

For any scarce resource we can consider the value to the firm of gaining or losing units of that scarce resource.

For example, in TYU 1 above it was determined that labour hours were the limiting factor and with 5,000 hours available the maximum contribution that could be earned was $38,750 based on selling 1,000A, 1,750B and 6,000C.

Suppose one additional labour hour became available. This would allow the company to make and sell more units of product B (Note that this was the product being made when the labour hours ran out).

- Each unit of B takes 0.8 hours, so one additional hour would enable us to make 1.25 additional units of B.
- Each unit of B generates contribution of $5, so one additional hour would generate additional contribution of 1.25 × 5 = $6.25.
- Note that this is contribution so has already deducted the cost of the labour at $7.50 per hour.
- Thus the firm would be willing to pay up to 7.50 + 6.25 = $13.75 an hour for additional labour.

This concept is discussed further below under the topic of shadow prices.

3 Several limiting factors – linear programming

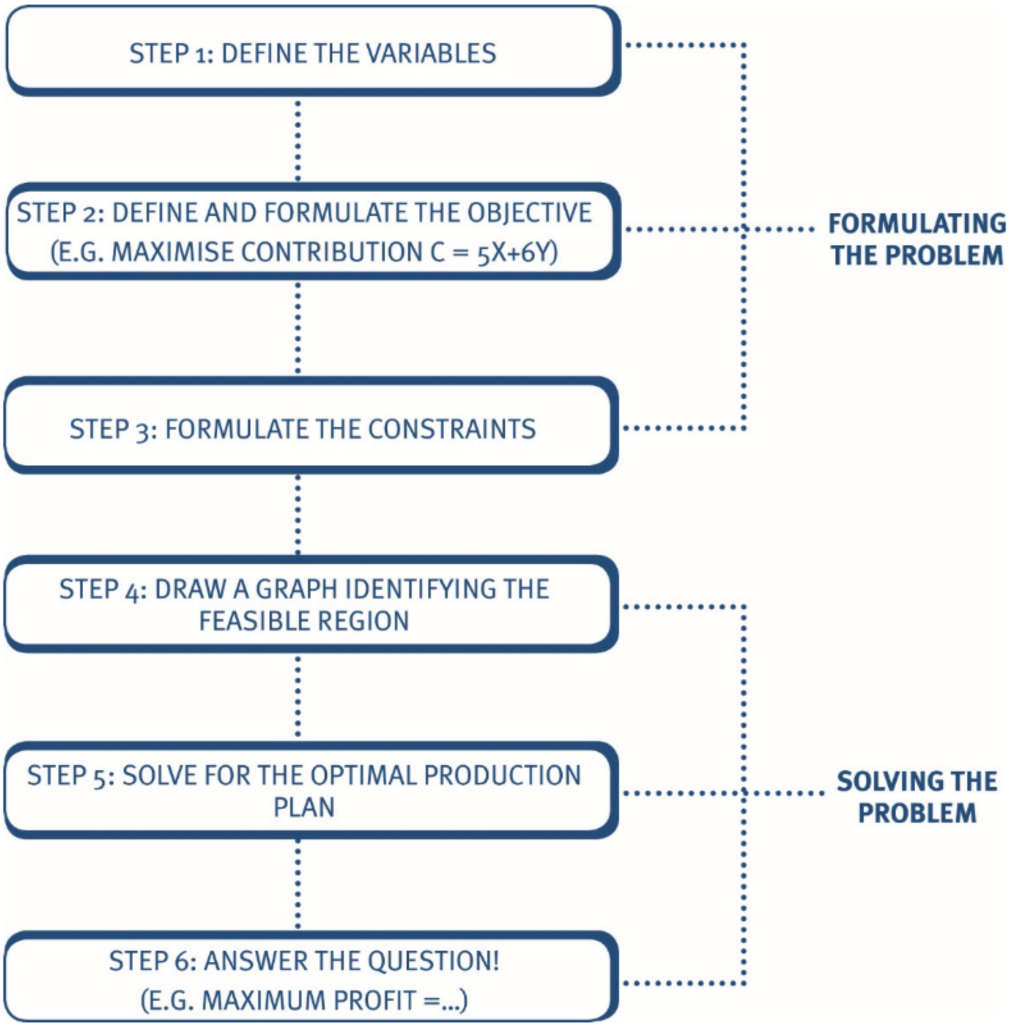
When there is only **one** scarce resource, the method above (key factor analysis) can be used to solve the problem. However where there are two or more resources in short supply which limit the organisation’s activities, then linear programming is required to find the solution.

In examination questions linear programming is used to:

- maximise contribution and/or
- minimise costs.

Formulating a linear programming problem involving two variables

The steps involved in linear programming are as follows:


STEP 1: DEFINE THE VARIABLES
STEP 2: DEFINE AND FORMULATE THE OBJECTIVE (E.G. MAXIMISE CONTRIBUTION C = 5X+6Y)
STEP 3: FORMULATE THE CONSTRAINTS
FORMULATING THE PROBLEM
STEP 4: DRAW A GRAPH IDENTIFYING THE FEASIBLE REGION
STEP 5: SOLVE FOR THE OPTIMAL PRODUCTION PLAN
STEP 6: ANSWER THE QUESTION! (E.G. MAXIMUM PROFIT =...)
SOLVING THE PROBLEM

Note: Linear programming calculations will only involve two variables in exam questions.

Illustration 1 – Linear programming

A company produces two products in three departments. Details are shown below regarding the time per unit required in each department, the available hours in each department and the contribution per unit of each product:

	Product X: hours per unit	**Product Y: hours per unit**	**Available hours**
Department A	8	10	11,000
Department B	4	10	9,000
Department C	12	6	12,000
Contribution p.u.	$4	$8	

There is unlimited demand for Product X, but demand for Product Y is limited to 600 units per annum.

Required:

Determine, using a step-by-step approach, what the optimum production plan is.

Solution

To determine what the optimum production plan is, we will follow the linear programming steps:

Step 1: Define the variables

Let 'x' be the number of units of X to produce; Let 'y' be the number of units of Y to produce.

Step 2: Define and formulate the objective function

Objective function: to maximise contribution $C = 4x + 8y$

Step 3: Formulate the constraints

Subject to:

- In Department A, $8x + 10y \leq 11{,}000$ hours
- In Department B, $4x + 10y \leq 9{,}000$ hours
- In Department C, $12x + 6y \leq 12{,}000$ hours
- Non-negativity constraint: $0 \leq x, y$.

Sales demand for Product Y is also a constraint that can be expressed by the inequality $y \leq 600$.

Step 4: Draw a graph identifying the feasible region

All the constraints are straight lines so each can be drawn by joining two points. In LP questions it is often easiest to get the two end points – i.e. where the lines cross the x and y axes.

To draw Constraint 1 (constraint in Department A), we take the inequality '$8x + 10y \leq 11{,}000$ hours' and turn it into an equation: $8x + 10y = 11{,}000$. To draw this constraint, we need two points.

- If X = 0, Y = 11,000 ÷ 10 so Y = 1,100
- Likewise, if Y = 0, X = 11,000 ÷ 8 so X = 1,375

To draw Constraint 2 (Department B):

- If X = 0, Y = 900 and
- If Y = 0, X = 2,250

To draw Constraint 3 (Department C):

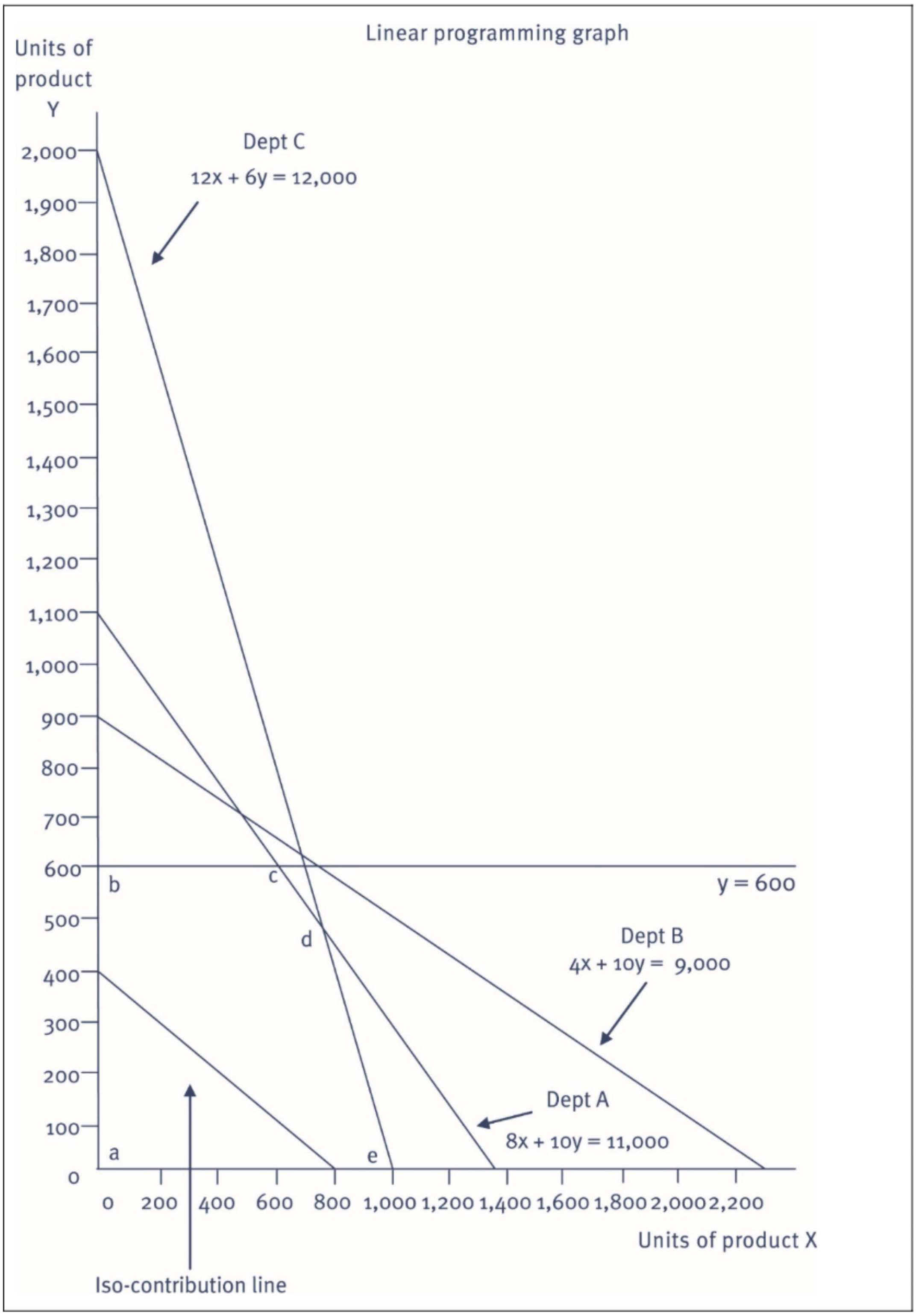
- If X = 0 , Y = 2,000 and
- If Y = 0, X = 1,000

To draw the final constraint (maximum demand for Product Y), we draw the line $y = 600$ for any value of x:

- If X = 0 , Y = 600 and
- If X = 100, Y = 600

For each constraint line, we then need to consider whether the acceptable (feasible) co-ordinates are below or above the line. All of the constraints here are " ≤ " types, so acceptable solutions are to the left/below the lines giving the feasible region ABCDE.

Learning to draw a graph to scale will provide a firm foundation for your understanding of linear programming graphs. To give yourself some practice, it would be a good idea to produce your own chart on a piece of graph paper. You will not be asked to draw graphs in your exam but you may be asked to interpret one. Knowing how they are constructed will help you answer these types of questions.


Linear programming graph
Units of product Y
2,000
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
Dept C
12x + 6y = 12,000
b
c
y = 600
d
Dept B
4x + 10y = 9,000
Dept A
8x + 10y = 11,000
a
e
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
Units of product X
Iso-contribution line

Step 5: Finding the optimum solution – Using the iso-contribution line

The maximum value of the objective function is not known; however, we can draw an iso-contribution (or 'profit') line that shows all the combinations of x and y that provide the same total value for the objective function.

If, for example, we need to maximise contribution \$4x + \$8y, we can draw a line on a graph that shows combination of values for x and y that give the same total contribution, when x has a contribution of \$4 and y has a contribution of \$8.

Any total contribution figure can be picked, but a multiple of \$4 and \$8 is easiest.

- For example, assume 4x + 8y = 4,000. This contribution line could be found by joining the points on the graph x = 0, y = 500 and x = 1,000 and y = 0.
- Instead, we might select a total contribution value of 4x + 8y = \$8,000. This contribution line could be found by joining the points on the graph x = 0, y = 1,000 and x = 2,000 and y = 0.
- When drawing both of these contribution lines on a graph, we find that the two lines are parallel and the line with the higher total contribution value for values x and y (\$8,000) is further away from the origin of the graph (point 0).
- This can be used to identify the solution to a linear programming problem. Draw the iso-contribution line showing combinations of values for x and y that give the same total value for the objective function.
- Look at the slope of the contribution line and, using a ruler, identify which combination of values of x and y within the feasible area for the constraints is furthest away from the origin of the graph. As this is a 'maximising' problem (we aim to 'maximise' contribution), we will try and maximise the distance between the origin and the optimum point.(*)

  The optimum point is the combination of values for x and y where an iso-contribution line can be drawn as far to the right as possible that just touches one corner of the feasible area. This is the combination of values of x and y that provides the solution to the linear programming problem.

Optimum corner is Corner C, the intersection of:

8x + 10y = 11,000 and y = 600
At this corner, x = 625 and y = 600.

The optimum production plan is to produce 625 units of Product X and 600 units of Product Y; The contribution at this point is maximised C = (625 × \$4) + (600 × \$8) = \$7,300.

(*) If, on the other hand, we were faced with a 'minimising' problem, i.e. a question where we have to minimise costs (and not maximise contribution), we would aim to slide the ruler as close to the origin as possible.

Test your understanding 2 – Steps 1 to 3

Hebrus Inc manufactures summerhouses and garden sheds. Each product passes through a cutting process and an assembly process. One summerhouse, which makes a contribution of $50, takes six hours' cutting time and four hours' assembly time; while one shed makes a contribution of $40, and takes three hours' cutting time and eight hours' assembly time. There is a maximum of 36 cutting hours available each week and 48 assembly hours.

Cutters are paid $10 per hour and assembly workers $15 per hour.

Required:

Formulate the linear programming problem.

Drawing the graph

- Step 4 of the linear programming model is to represent the constraints as straight lines on a graph.
- In order to plot the constraints it is normally best to compute the intercepts of the equalities on the horizontal and vertical axes. Thus, x and y are each set equal to zero in turn and the value of y and x computed in these circumstances.

Revision of graphing a straight line

Step 4 of the linear programming model is to represent the constraints as straight lines on a graph. We do this below. In the meantime, this section contains basic revision for students who are not familiar with the process of graphing a straight line.

To begin with, we must have a linear relationship between two measurements.

Examples $y = 3x + 1$

$y = 2x + 42$ etc.

Note:

(1) To recognise a linear relationship the equation must have only ‘x’ not ‘x’ to the power of anything, e.g. x^2.

(2) A straight line has two characteristics:

   (i) a slope or gradient – which measures the ‘steepness’ of the line

   (ii) a point at which it cuts the y axis – this is called the intercept:

   $y = (\text{slope} \times x) + \text{intercept}$

   e.g. $y = 2x + 3$

Therefore, the gradient is 2 and the point at which the line cuts the y axis is 3.

To draw a straight line graph we only need to know two points that can then be joined.

Consider the following two equations:

(i) $y = 2x + 3$

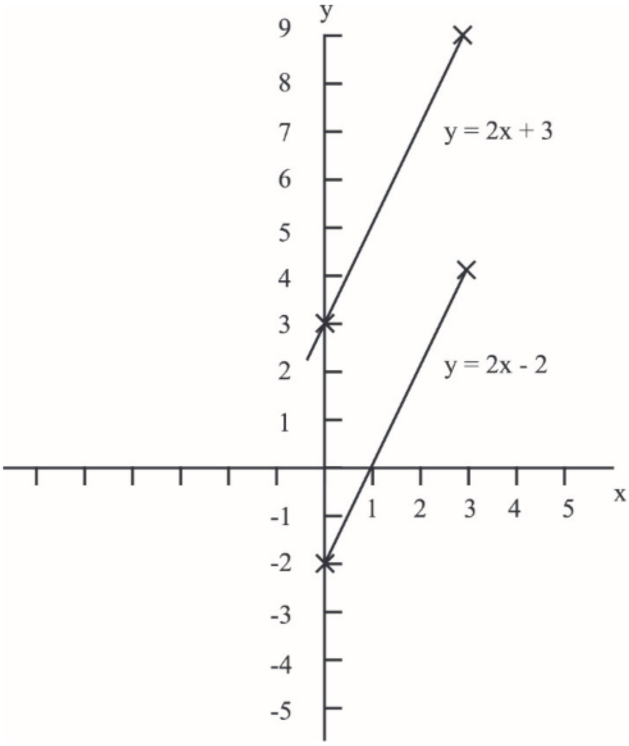
(ii) $y = 2x - 2$

In order to draw the graphs of these equations it is necessary to decide on two values for x and then to calculate the corresponding values for y. Let us use $x = 0$ and 3. These calculations are best displayed in tabular form.

(i) $(x = 0, y = 3)$ and $(x = 3, y = 9)$

(ii) $(x = 0, y = -2)$ and $(x = 3, y = 4)$

So to draw the first line we plot the points (0, 3) and (3, 9) and simply join them up. Similarly, for the second line we plot the points (0, –2) and (3, 4) and join them up.



Note: The lines are parallel because the equations have the same gradient of 2.

Test your understanding 3 – Step 4

Using the information from the Hebrus example (TYU 2) you are required to plot the constraints on a graph and indicate on the graph the feasible region.

Identifying the feasible region

- Having inserted the straight lines in the graph, we are then ready to work out what is called the feasible region.
- The feasible region shows those combinations of variables which are possible given the resource constraints.
- In the TYU above the original constraints were '≤' types, so the feasible region is shown by the area bounded by the thick black line on the graph. Production can be anywhere in this area.
- The lines drawn on the graph represent equations where the LHS equals the RHS. However, the original constraint was either '≤' or '≥'.
- A '≤' type constraint is represented by all points on the line AND all points in the area below the line (i.e. nearer to the origin – the point x = 0,y = 0).
- A '≥' type constraint is represented by all points on the line AND all points in the area above the line (i.e. away from the origin).
- Watch out in the examination for constraints that show minimum amounts required as well as maximum amounts of constraints available. Typically in questions these tend to be a government quota that a minimum amount of one of the output needs to be produced.

Finding the optimal solution using the graph

Having found the feasible region the problem now is to find the optimal solution within this feasible region.

There are two approaches to this final stage.

- **By inspection** it is clear that the maximum contribution will lie on one of the corners of the feasible region. The optimal solution can be reached simply by calculating the contributions at each corner. This approach is not recommended in the exam since it tends to be quite time consuming.
- **By drawing an iso-contribution line** (an objective function for a particular value of C), which is a line where all points represent an equal contribution. This is the recommended approach, particularly for more complex problems.

Test your understanding 4 – Steps 5 and 6

Using the Hebrus example again (TYU 2 and 3) you are required to find the optimal solution using the graph (Step 5).

Calculate the contribution at this point (Step 6).

Solving the problem using simultaneous equations

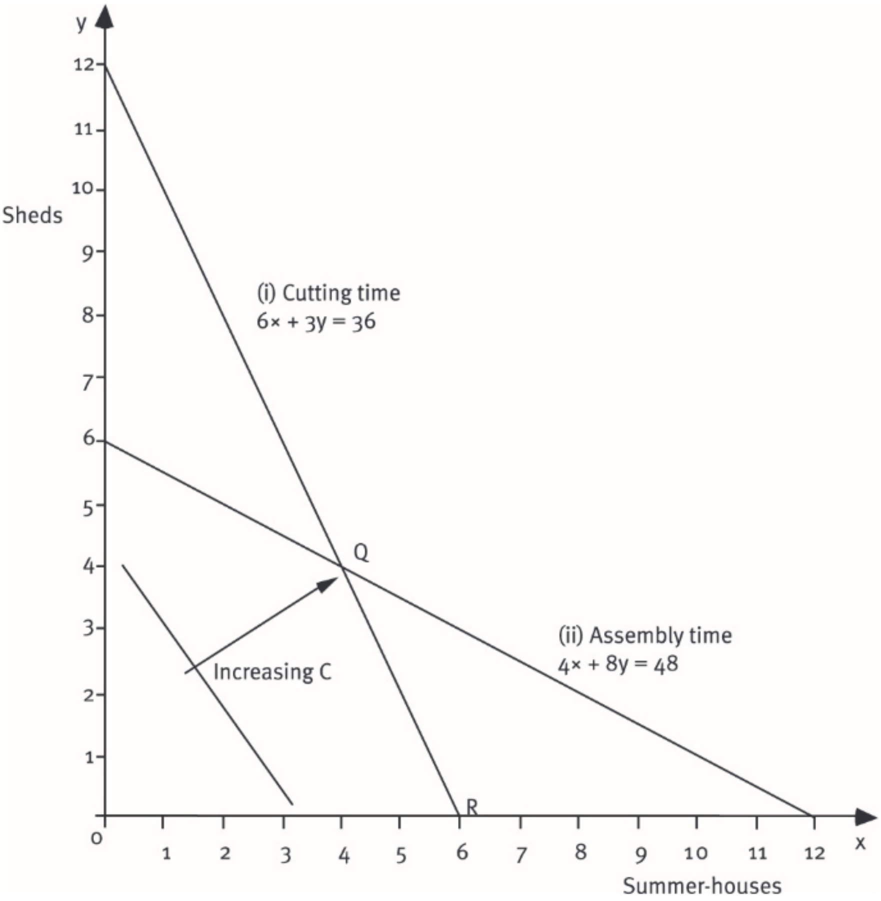
In the exam, you will not be required to produce a graph yourself, however you may need to interpret a diagram that has been provided for you. As an alternative, you can use simultaneous equations to find the optimal solution in situations where a graph has not been provided, or where more accuracy is needed.

The technique can be used as a check, or to establish the exact quantities for the optimal solution when the graph does not give sufficient accuracy.

Test your understanding 5 – Simultaneous equations

Using the Hebrus example again (TYU 2 – 4) you are required to use simultaneous equations to verify the optimal point.

You will need the linear programming graph to see which constraints intersect, and Hebrus' graph has been correctly drawn as follows:



Test your understanding 6 – Additional example

Alfred Co is preparing its production plan for the coming month. It manufactures two products, the flak trap and the sap trap. Details are as follows.

	Product		**Price/wage rate**
	Flak trap	**Sap trap**	
Amount/unit			
Selling price ($)	125	165	
Raw material (kg)	6	4	$5/kg
Labour hours:			
Skilled	10	10	$3/hour
Semi-skilled	5	25	$3/hour

The company's fixed overhead absorption rate (OAR) is $1/labour hour (for both skilled and semi-skilled labour). The supply of skilled labour is limited to 2,000 hours/month and the supply of semi-skilled labour is limited to 2,500 hours/month. At the selling prices indicated, maximum demand for flak traps is expected to be 150 units/month and the maximum demand for sap traps is expected to be 80 units/month.

Required:

(a) Formulate the constraints for Alfred Co.

(b) Plot the constraints on a graph and indicate on the graph the feasible region.

(c) Using the graph find the optimal production plan.

(d) Use simultaneous equations to accurately calculate the quantities produced at the optimal point and calculate the maximum contribution at this point.

Test your understanding 7 – Minimising costs

J Farms Ltd can buy two types of fertiliser which contain the following percentage of chemicals:

	Nitrates	**Phosphates**	**Potash**
Type X	18	5	2
Type Y	3	2	5

For a certain crop the following minimum quantities (kg) are required:

Nitrates 100	Phosphates 50	Potash 40

Type X costs $10 per kg and type Y costs $5 per kg. J Farms Ltd currently buys 1,000 kg of each type and wishes to minimise its expenditure on fertilisers.

(a) Formulate the objective function and the constraints for J Farms Ltd.

(b) Draw a graph to illustrate all the constraints (equations/ inequalities), shading the feasible region.

(c) Recommend the quantity of each type of fertiliser which should be bought and the cost of these amounts.

(d) Find the saving J Farms Ltd can make by switching from its current policy to your recommendation.

Limiting factor analysis – discussion aspects

Assumptions

- There is a single quantifiable objective – e.g. maximise contribution. In reality there may be multiple objectives such as maximising return while simultaneously minimising risk.
- Each product always uses the same quantity of the scarce resource per unit. In reality this may not be the case. For example, learning effects may apply.
- The contribution per unit is constant. In reality this may not be the case:
  - the selling price may have to be lowered to sell more
  - there may be economies of scale, for example a discount for buying in bulk.
- Products are independent – in reality:
  - customers may expect to buy both products together
  - the products may be manufactured jointly together.
- The scenario is short term. This allows us to ignore fixed costs.

The assumptions apply to the analysis used when there is one limiting factor or if there are multiple limiting factors.

4 Shadow prices and slack

When discussing constraints, **slack** is the amount by which a resource is under-utilised, i.e. slack occurs when the maximum availability of a resource is not used. Graphically speaking, it will occur when the optimum point does not fall on a given resource line.

- The optimal solution will typically occur where two ("critical") constraint lines cross. There will be no slack for these constraints/resources as they will be fully utilised.
- For other constraint lines, the fact that the optimal solution is not on these lines means that the resources are not fully utilised, so there will be slack.

Slack is important for two reasons

- For critical constraints (zero slack), then gaining additional units of these scarce resources will allow the optimal solution to be improved (e.g. higher contribution earned). Similarly if another department wants these resources then it will result in lower contribution.
- For non-critical constraints, gaining or losing a small number of units of the scarce resource will have no impact on the optimal solution.

To determine how much this makes scarce resources worth to the business, see the section below on "shadow prices".

Note: The term 'slack' can also apply to a product i.e. there can be unfulfilled demand.

Illustration 2 – Slack

Illustration 1

In Illustration 1 we solved the following problem:

Objective function: to maximise contribution C = 4x + 8y Subject to:

- Department A time, $8x + 10y \le 11{,}000$
- Department B time, $4x + 10y \le 9{,}000$
- Department C time, $12x + 6y \le 12{,}000$
- Non-negativity constraint: $0 \le x, y$.
- $y \le 600$

The optimal solution ($x = 625$, $y = 600$) was found where the department A and Product Y constraints crossed.

We can therefore say:

- Department A time is a critical constraint with no slack.
- Product Y constraint is a critical constraint with no slack.

- For Department B time, actual amount used = 4x + 10y = 4 × 625 + 10 × 600 = 8,500. The maximum amount available was 9,000 giving slack of 500 hours.
- For Department C time, actual amount used = 12x + 6y = 12 × 625 + 6 × 600 = 11,100. The maximum amount available was 12,000 giving slack of 900 hours.

Hebrus (TYU 2 – 5)

In the Hebrus example, the optimum point Q lies on both the cutting and assembly time lines.

Therefore both resources are fully utilised and are referred to as critical constraints.

Alfred Co (TYU 6)

In the Alfred Co example, the optimum point D (x = 150, y = 50) lies on the intersection of the skilled labour line (10x + 10y = 2,000) and the maximum demand line for flak traps (x = 150).

At this point there is unutilised semi-skilled labour. This means that slack exists for semi-skilled labour.

The amount of semi-skilled labour used = 5x + 25y = 5 × 150 + 25 × 50 = 2,000 compared to a maximum available of 2,500 thus giving slack of 500 hours.

Semi-skilled labour is a non-critical constraint and this unutilised resource should be used elsewhere in the business to generate contribution.

Shadow (or dual) prices

The shadow price or dual price of a limiting factor is the increase in contribution created by the availability of one additional unit of the limiting factor at the original cost.

- The shadow price of a resource can be found by calculating the increase in value (usually extra contribution) which would be created by having available one additional unit of a limiting resource at its original cost.
- It therefore represents the maximum **premium** that the firm should be willing to pay for one extra unit of each constraint. This aspect is discussed in more detail below.
- Non-critical constraints will have zero shadow prices as slack exists already.

Calculating shadow prices

The simplest way to calculate shadow prices for a critical constraint is as follows:

Step 1: Take the equations of the straight lines that intersect at the optimal point. Add one unit to the constraint concerned, while leaving the other critical constraint unchanged.

Step 2: Use simultaneous equations to derive a new optimal solution.

Step 3: Calculate the revised optimal contribution and compare to the original contribution calculated. The increase is the shadow price.

Test your understanding 8 – Shadow prices

In Hebrus the optimal solution was determined to be x = 4 and y = 4 giving an optimal contribution of $360. This solution was at the intersection of the lines:

Cutting	$6x + 3y$	=	36
Assembly	$4x + 8y$	=	48

Required:

Suppose one extra hour was available for the cutting process. Calculate the shadow price for this additional hour of cutting time.

Additional example on shadow prices

Using the following data, calculate the shadow price for machining time.

Maximise C = 80x + 75y (contribution), subject to

(i) $20x + 25y \leq 500$ (machining time)

(ii) $40x + 25y \leq 800$ (finishing time)

The optimal solution at the intersection of the above constraints is: x = 15, y = 8.

Solution

Step 1: Machining time – the constraints become:

(i) $20x + 25y \leq 501$

(ii) $40x + 25y \leq 800$

Step 2: Subtracting (i) from (ii) gives 20x = 299 and thus x = 14.95

Inserting into (i) gives

$(20 \times 14.95) + 25y = 501$

$25y = 202$

$y = 8.08$

Step 3: Original contribution = (15 × \$80) + (8 × \$75) = \$1,800.

Amended contribution = (14.95 × \$80) + (8.08 × \$75) = \$1,802.

The shadow price per machine hour is thus \$2.

Implications of shadow prices

- Management can use shadow prices as a measure of the maximum premium that they would be willing to pay for one more unit of the scarce resource.
- However, the shadow price should be considered carefully. For example, the shadow price of labour may be calculated as \$20 per hour. However, it may be possible to negotiate a lower shadow price than this.
- In addition, if more of the critical constraint is obtained, the constraint line will move outwards altering the shape of the feasible region. After a certain point there will be little point in buying more of the scarce resource since any non-critical constraints will become critical.

Additional example on linear programming

Suppose a linear programming problem gives the following results.

Constraint	**Normal cost**	**Shadow price**
Skilled labour	\$20/hour	\$12/hour
Unskilled labour	\$10/hour	zero
Materials	\$5/kg	\$3/kg

Required:

(a) Which two constraints give rise to the optimal solution?

(b) Overtime is paid at 'time-and-a-half'. Is it worth paying overtime to help relax constraints?

(c) A new product has been proposed with the following proposed costs and revenues.

	$
Selling price	80
Skilled labour – 2 hours @ $20/hour	(40)
Unskilled labour – 1 hour @ $10/hour	(10)
Materials – 3 kg @ $5/kg	(15)
Profit per unit	15

Assuming that the constraints cannot be relaxed, should the new product be manufactured?

Solution

(a) Critical constraints have non-zero dual prices, so the optimal solution will be at the intersection of skilled labour and materials.

(b) For skilled labour overtime will cost $30 per hour and the benefit will be 20 + 12 = $32 per hour. The overtime is thus worthwhile and will generate a net $2 per hour benefit.

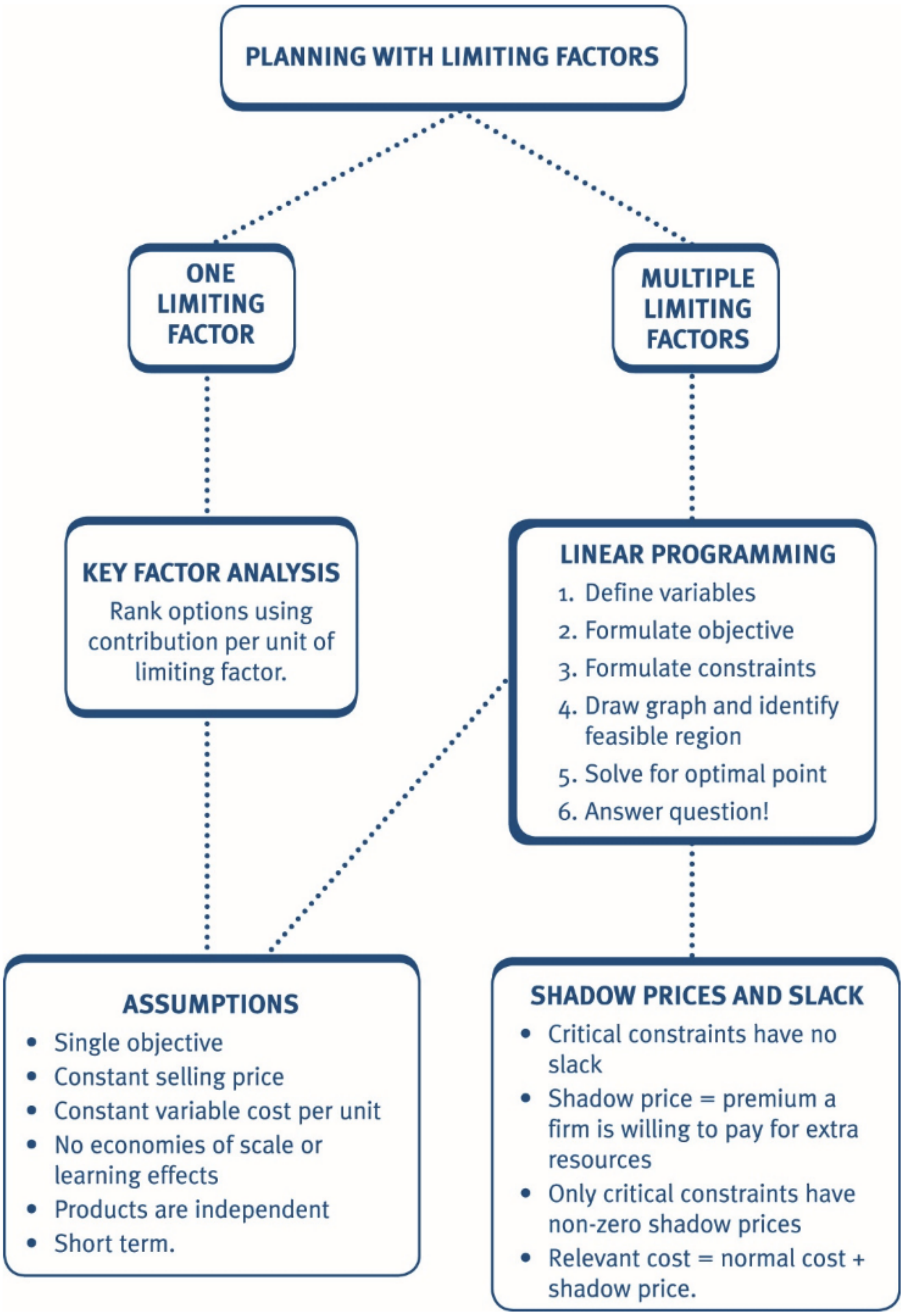
For unskilled labour there is already slack so overtime is not worthwhile.

(c) The profit statement can be revised using as follows:

	$
Selling price	80
Skilled labour – 2 hours @ (20 + 12)	(64)
Unskilled labour – 1 hour @ 10	(10)
Materials – 3 kg @ (5 + 3)	(24)
Loss per unit	(18)

Incorporating the contribution lost elsewhere by reallocating scarce resources, the new product is not viable.

5 Chapter summary



PLANNING WITH LIMITING FACTORS

ONE LIMITING FACTOR

MULTIPLE LIMITING FACTORS

KEY FACTOR ANALYSIS

Rank options using contribution per unit of limiting factor.

LINEAR PROGRAMMING

1. Define variables
2. Formulate objective
3. Formulate constraints
4. Draw graph and identify feasible region
5. Solve for optimal point
6. Answer question!

ASSUMPTIONS

- Single objective
- Constant selling price
- Constant variable cost per unit
- No economies of scale or learning effects
- Products are independent
- Short term.

SHADOW PRICES AND SLACK

- Critical constraints have no slack
- Shadow price = premium a firm is willing to pay for extra resources
- Only critical constraints have non-zero shadow prices
- Relevant cost = normal cost + shadow price.

Test your understanding answers

Test your understanding 1

Step 1: Identify the scarce resource (this may be done for you in examination questions).

At potential sales level:

	Sales potential units	**Total machine hours**	**Total labour hours**
Product A	4,000	40,000	4,800
Product B	6,000	72,000	4,800
Product C	6,000	84,000	2,400
		196,000	**12,000**

Thus, labour hours are the limiting factor.

Step 2: calculate the contribution per unit for each product. This has been done for us in the question.

Step 3: calculate the contribution per unit of the scarce resource for each product, i.e. per labour hour.

Product A $6/1.2 = $5.00 Product B $5/0.8 = $6.25 Product C $4/0.4 = $10.00

Step 4: rank the products in order of the contribution per unit of the scarce resource.

Thus, production should be concentrated first on C, up to the maximum available sales, then B, and finally A.

However, a minimum of 1,000 units of A must be produced.

Step 5: allocate resources using this ranking and answer the question, i.e. state the maximum contribution.

Taking these factors into account, the production schedule becomes:

	Units produced	**Labour hours**	**Cumulative labour hours**	**Limiting factor**
Product A	1,000	1,200	1,200	Policy to produce 1,000 units
Product C	6,000	2,400	3,600	Sales
Product B	1,750	1,400	5,000	Labour hours

The maximum contribution is therefore as follows.

	$
A (1,000 × \$6)	6,000
B (1,750 × \$5)	8,750
C (6,000 × \$4)	24,000
	38,750

Test your understanding 2 – Steps 1 to 3

Step 1 – define the variables

Let x = the number of summerhouses produced each week

y = the number of garden sheds produced each week.

(**Note**: Be careful to specify the time periods involved.)

Step 2 – define and formulate the objective function.

The objective here is to maximise contribution C, given by:

Maximise contribution = $50x + 40y$

Step 3 – formulate the constraints.

The constraints (limitations) here are the amounts of cutting and assembly time available.

If 1 summerhouse requires 6 hours' cutting time,

x summerhouses require 6x hours' cutting time.

If 1 shed requires 3 hours' cutting time,

y sheds require 3y hours' cutting time.

Hence total cutting time required = $6x + 3y$ hours.

Similarly, if one summerhouse and one shed require 4 and 8 hours' assembly time respectively, the total assembly time for x summerhouses and y sheds will be $4x + 8y$.

The conventional way of setting out the constraints is to place the units **utilised** on the left, and those **available** on the right; the inequality sign is the link.

Constraint		**Utilised**		**Available**
Cutting time	(i)	$6x + 3y$	≤	36
Assembly time	(ii)	$4x + 8y$	≤	48

In addition, two other logical constraints must be stated, i.e. $x > 0$ and $y > 0$

These simply state that negative amounts of garden sheds or summerhouses cannot be made.

Test your understanding 3 – Step 4

The cutting time constraint is an inequality $6x + 3y \leq 36$ which represents a region on the graph. To identify this region we draw the line $6x + 3y = 36$ (equality) and then determine which side of the line is feasible. This process is repeated for each constraint.

For the equation $6x + 3y = 36$ – cutting time constraint

when $x = 0$, $y = 36/3 = 12$ and when $y = 0$, $x = 36/6 = 6$

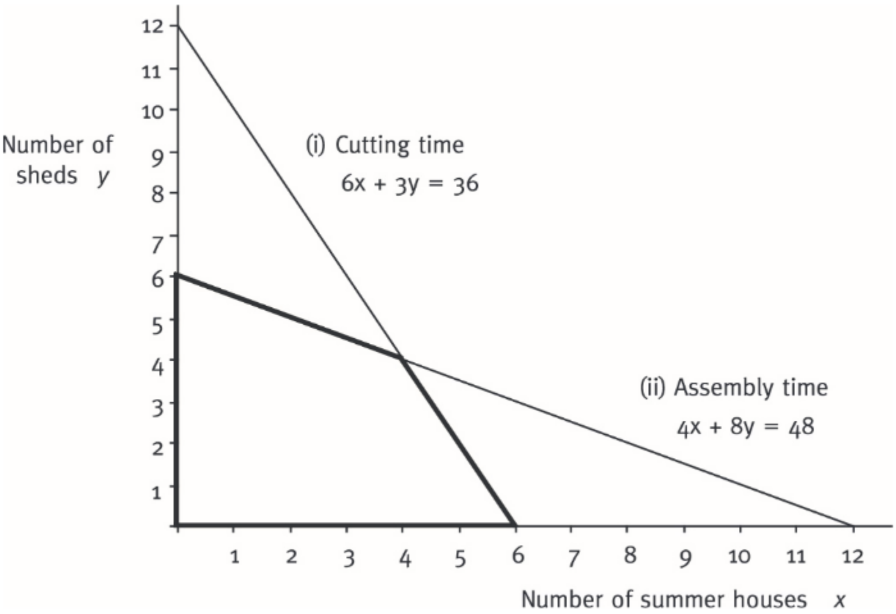
To graph this constraint, we draw a straight line between the points (0, 12) and (6, 0).

For the equation $4x + 8y = 48$ – assembly time constraint

when $x = 0$, $y = 48/8 = 6$ and when $y = 0$, $x = 48/4 = 12$

To graph this constraint, we draw a straight line between the points (0, 6) and (12, 0).

The constraints can now be represented graphically:



The original constraints were '≤' types, so the feasible region is shown by the area bounded by the thick black line on the graph. Production can be anywhere in this area.

Test your understanding 4 – Steps 5 and 6

Step 5: Finding the optimal solution using the graph.

Let's first consider what we mean by an iso-contribution line.

An iso-contribution line is a line where all the points represent an equal contribution.

The contribution for Hebrus is given by the equation, C = 50x + 40y (from Step 2).

- If we choose a contribution of, say, $200 we can draw an iso-contribution line 200 = 50x + 40y

  when x = 0, y = 200/40 = 5

  when y = 0, x = 200/50 = 4

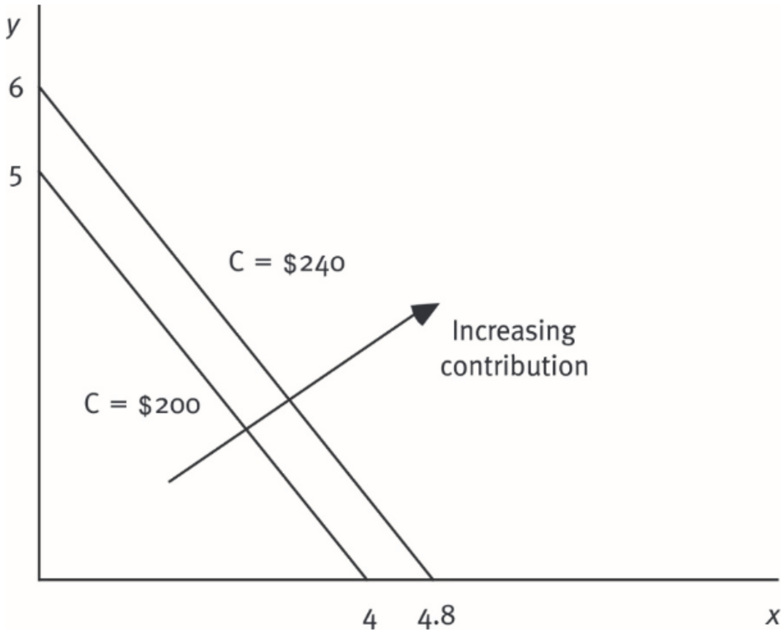
  To graph the line, we draw a straight line between the points (0, 5) and (4, 0). This line is shown on the graph below.

- If we choose another contribution of, say, $240 we can draw an iso-contribution line 240 = 50x + 40y

  when x = 0, y = 240/40 = 6

  when y = 0, x = 240/50 = 4.8

  To graph the line, we draw a straight line between the points (0, 6) and (4.8, 0). This line is shown on the graph below.



The iso-contribution lines move to and from the origin in parallel; the arrow indicates increasing contribution. The object is to get on the highest contribution line within (just touching) the binding constraints.

The optimum point is found by drawing an example of an iso-contribution line on the diagram (any convenient value of C will do), and then placing a ruler against it. Then, by moving the ruler away from the origin (in the case of a maximisation problem) or towards the origin (in the case of a minimisation problem) but keeping it parallel to the iso-contribution line, the last corner of the feasible solution space which is met represents the optimum solution.

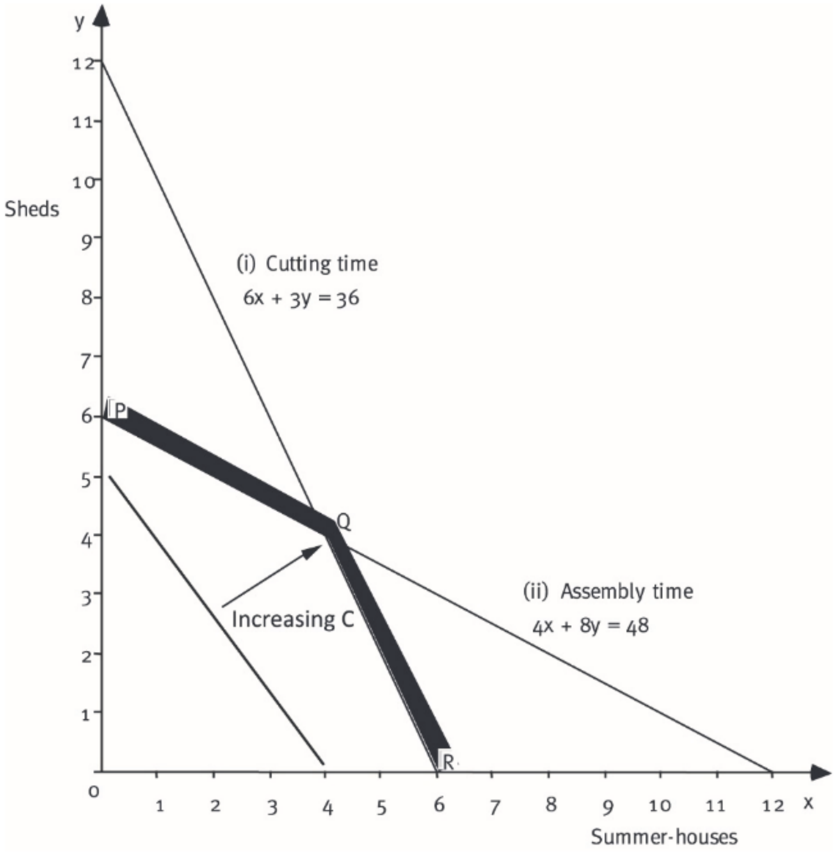
To find the optimal point for Hebrus we have used an iso-contribution line for a contribution of $200. However, either of the iso-contribution lines discussed above, or another iso-contribution line, could have been used instead.

$200 = 50x + 40y$

when $x = 0$, $y = 200/40 = 5$

when $y = 0$, $x = 200/50 = 4$

To graph the line, we draw a straight line between the points (0, 5) and (4, 0). This line is shown on the graph below.



Optimal point: The highest available iso-contribution line occurs at point Q.

Step 6: Answer the question, i.e. calculate the contribution at the optimal point.

Reading from the graph, at point Q $x = 4$ and $y = 4$. This gives a maximum contribution of $C = (50 \times 4) + (40 \times 4) = \$360$.

Test your understanding 5 – Simultaneous equations

Step 1: Take the equations of the two constraints that cross at the optimal point.

The optimal point is point Q. This is at the intersection of the two constraint lines:

4x + 8y = 48 this will be called (a)

6x + 3y = 36 this will be called (b)

Step 2: Multiply both equations in order to get the same number of x's or y's in each equation.

(a) multiplied by 3 gives 12x + 24y = 144

(b) multiplied by 2 gives 12x + 6y = 72

Step 3: Subtract one equation from the other to eliminate either x or y.

(a) 12x + 24y = 144

minus (b) 12x + 6y = 72

gives 0x + 18y = 72

Therefore, y = 72/18 = 4 (this is the same number of garden sheds found using the graph).

Step 4: Use any equation to find the missing value, i.e. either x or y.

Using the value y = 4 we can find the value of x. Any of the equations above can be used. For example:

4x + 8y = 48

4x + (8 × 4) = 48

4x = 16

x = 16/4 = 4 (this is the same number of summerhouses found using the graph).

Step 5: Answer the question.

The optimal point is at x = 4 and y = 4. This gives a maximum contribution of C = (50 × 4) + (40 × 4) = $360 (as per TYU4).

Test your understanding 6 – Additional example

(a) **Step 1: define variables**

Let x = the number of units of flak traps produced per month.

y = the number of units of sap traps produced per month.

Step 2: objective function

The objective is to maximise contribution, C, given by C = 50x + 40y (Working)

Working:

Contribution per flak trap = 125 – (6 × 5) – (10 × 3) – (5 × 3) = 50

Contribution per sap trap = 165 – (4 × 5) – (10 × 3) – (25 × 3) = 40

Step 3: constraints

Skilled labour	10x + 10y	≤ 2,000
Semi-skilled labour	5x + 25y	≤ 2,500
Max demand	x	≤ 150
	y	≤ 80
Non-negativity	x,y	≥ 0

(b) **Step 4: draw a graph and identify the feasible region**

Skilled labour: x = 0, y = 2,000/10 = 200

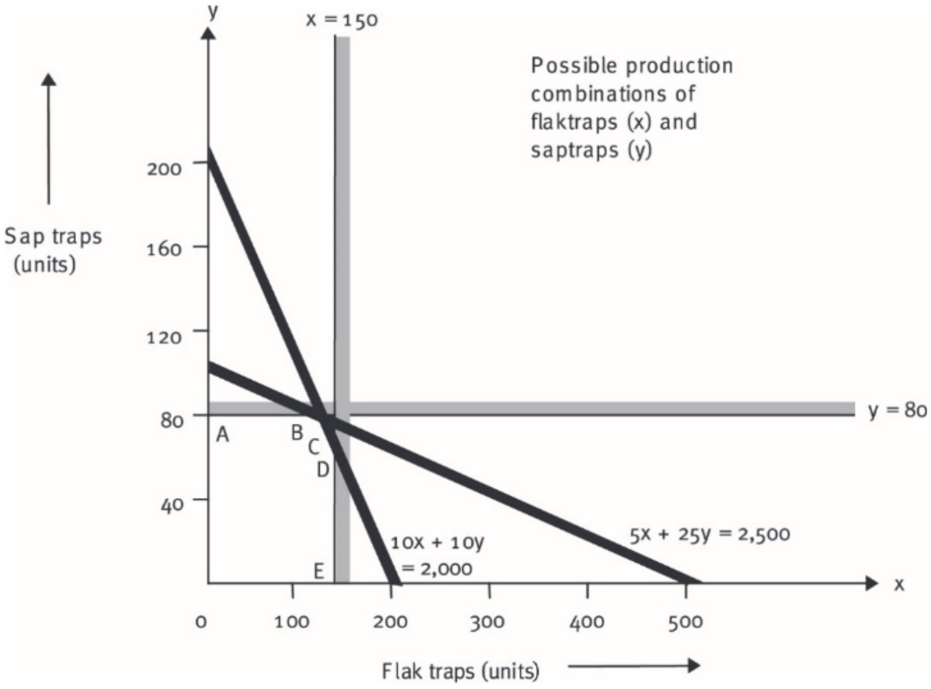
y = 0, x = 2,000/10 = 200

We simply join up the points (0, 200) and (200, 0).

Semi-skilled labour: x = 0, y = 2,500/25 = 100

y = 0, x = 2,500/5 = 500

We join up the points (0, 100) and (500, 0)

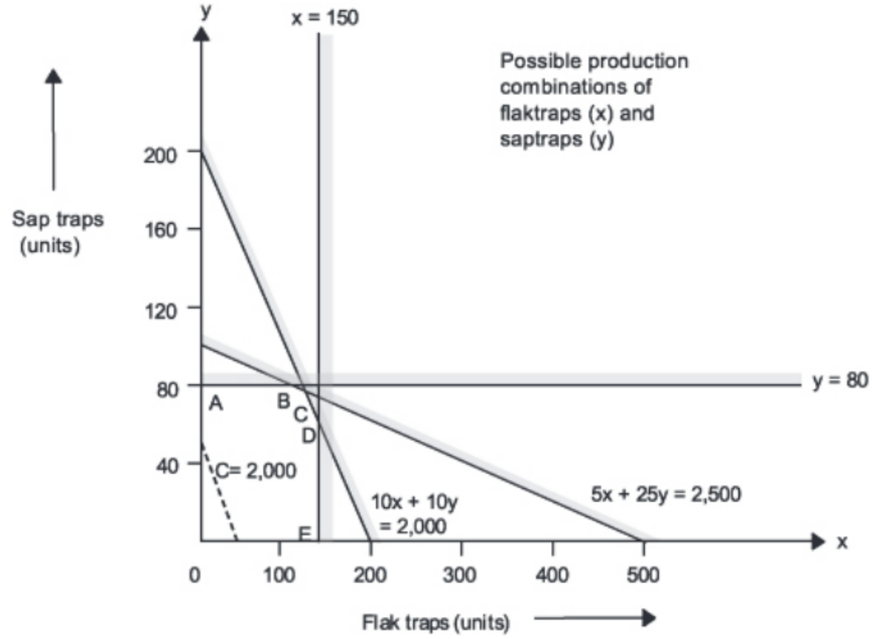


This gives a feasibility region of 0ABCDE.

(c) **Step 5: use the graph to solve the optimal production plan**

Objective is to maximise contribution C = 50x + 40y.

The iso-contribution line C = 2,000 has been drawn to establish the gradient and identify the optimal solution at point D:



It is difficult to read the precise co-ordinates for point D but it is at the intersection of the two lines x = 150 and 10x + 10y = 2,000. This corresponds to 150 units of x (flak traps) and approximately 50–60 units of y (sap traps). The exact amounts can be found using simultaneous equations (see below).

(d) **Use simultaneous equations to accurately calculate the quantities produced at the optimal point and calculate the maximum contribution at this point.**

Take the equations of the two constraints that cross at the optimal point.

The optimal point is point D. This is at the intersection of the two constraint lines:

x = 150 this will be called (a)

10x + 10y = 2,000 this will be called (b)

Find the value of x

The solution is slightly easier here since we already know that x = 150, i.e. we should produce 150 flak traps.

Use any equation to find the missing value, i.e. y

Using the value x = 150 we can find the value of y.

10x + 10y = 2,000

(10 × 150) + 10y = 2,000

10y = 500

y = 500/10 = 50, i.e. we should produce 50 sap traps

Step 6: answer the question

The optimal point is at x = 150 and y = 50. This gives a maximum contribution of C = (50 × 150) + (40 × 50) = $9,500.

Test your understanding 7 – Minimising costs

(a) The chemicals are given in percentage terms that are converted to decimals.

Step 1: define the variables

Let x = number of kg of X purchased

Let y = number of kg of Y purchased

Step 2: define and formulate the objective function

Total cost: z = 10x + 5y, the objective function which has to be minimised.

Step 3: formulate the constraints

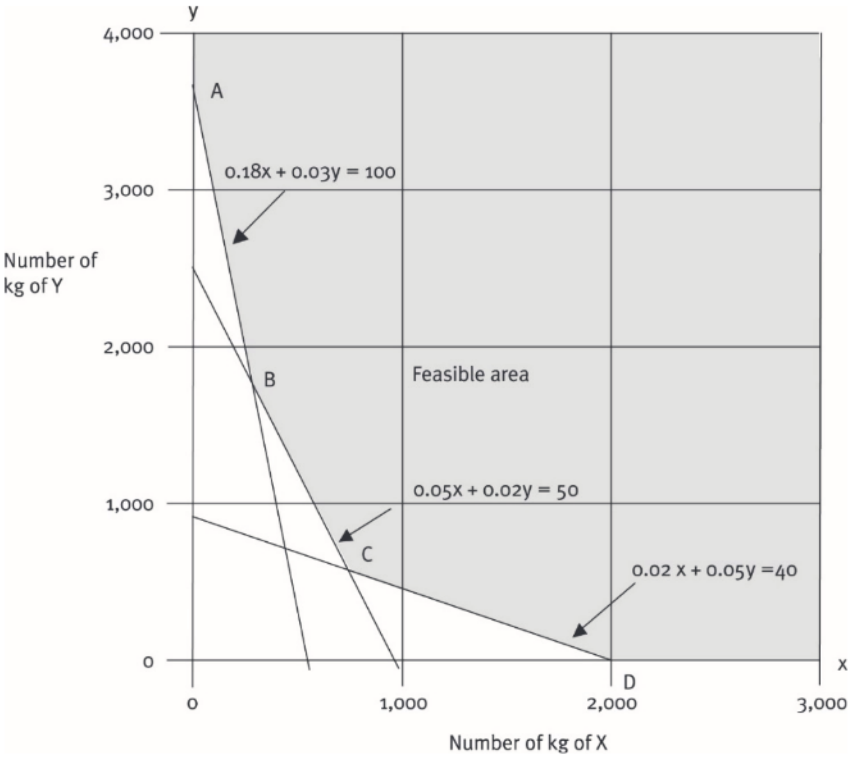
The constraints exist on the chemical composition of the fertilisers:

Nitrates:	$0.18x + 0.03y$	≥ 100
Phosphates:	$0.05x + 0.02y$	≥ 50
Potash:	$0.02x + 0.05y$	≥ 40
Non-negativity:	$x \geq 0$, $y \geq 0$	

(b) **Step 4: draw the graph and identify the feasible region**

In this example, all the points where the lines cut the axes are required, so that the easiest way to draw the constraints is to calculate these points.

Constraint	End points	
$0.18x + 0.03y = 100$	$x = 0$, $y = 100/0.03 = 3{,}333.3$	$y = 0$, $x = 100/0.18 = 555.5$
$0.05x + 0.02y = 50$	$x = 0$, $y = 50/0.02 = 2{,}500$	$y = 0$, $x = 50/0.05 = 1{,}000$
$0.02x + 0.05y = 40$	$x = 0$, $y = 40/0.05 = 800$	$y = 0$, $x = 40/0.02 = 2{,}000$



(c) **Step 5: find the optimal solution using the graph**

The inspection method has been used here, for illustration purposes only.

Considering the vertices (i.e. corners) of the feasible area.

A $x = 0$ $y = 3{,}333.3$

$z = 10x + 5y = 10(0) + 5(3{,}333.3) = \$16{,}666.50$

B Solving $0.18x + 0.03y = 100$ (a)

and $0.05x + 0.02y = 50$ (b)

Using simultaneous equations:

(a) × 2 gives $0.36x + 0.06y = 200$

(b) × 3 gives $0.15x + 0.06y = 150$

(a) – (b) gives $0.21x + 0y = 50$

$x = 50/0.21 = \mathbf{238.1}$

Substitute back into (a):

$(0.18 \times 238.1) + 0.03y = 100$

$0.03y = 57.1$

$y = 57.1/0.03 = \mathbf{1904.8}$

So $x = 238.1$ and $y = 1{,}904.8$

$z = 10(238.1) + 5(1{,}904.8) = \$11{,}905$

C Solving $0.05x + 0.02y = 50$ (c)

and $0.02x + 0.05y = 40$ (d)

Using simultaneous equations:

(c) × 5 gives $0.25x + 0.1y = 250$

(d) × 2 gives $0.04x + 0.1y = 80$

(c) – (d) gives $0.21x + 0y = 170$

$x = 170/0.21 = \mathbf{809.5}$

Substitute back into (c):

$(0.05 \times 809.5) + 0.02y = 50$

$0.02y = 9.53$

$y = 9.53/0.02 = \mathbf{476.2}$

So $x = 809.5$ and $y = 476.2$

$z = 10(809.5) = 5(476.2) = \$10{,}476$

D $x = 2{,}000$ $y = 0$

$z = 10(2{,}000) + 5(0) = \$20{,}000$

Step 6: answer the question

Thus C gives the point of minimum cost with x = 809.5 and y = 476.2, i.e. 809.5 kg of X and 476.2 kg of Y, total cost $10,476.

or:

Alternatively, an iso-cost line for z = 20,000 (say) could be plotted and moved downwards. This would identify point C as the optimum point on the graph, and the values of x and y could be determined using simultaneous equations as above. This would be quicker in the exam and the method should give the same answer.

(d) The current policy costs: 1,000 ($10) + 1,000 ($5) = $15,000, so the saving made is of $(15,000 – 10,476) = $4,524.

Test your understanding 8 – Shadow prices

Step 1: Take the equations of the straight lines that intersect at the optimal point. Add one unit to the constraint concerned, while leaving the other critical constraint unchanged.

We would then need to solve:

Cutting $6x + 3y = 37$
Assembly $4x + 8y = 48$

Step 2: Use simultaneous equations to derive a new optimal solution.

Solving $6x + 3y = 37$ (a)

and $4x + 8y = 48$ (b)

Using simultaneous equations:

(a) × 2 gives $12x + 6y = 74$

(b) × 3 gives $12x + 24y = 144$

(b) – (a) gives $0x + 18y = 70$

$y = 70/18 =$ **3.888...**

Substitute back into (a):

$6x + (3 \times 3.888...) = 37$

$6x = 25.333...$

$x = 25.333.../6 =$ **4.222...**

This gives and optimum vale of y = 3.888… and x = 4.222…

Step 3: Calculate the revised optimal contribution. The increase is the shadow price for the constraint under consideration.

The contribution. C = 50x + 40y.

At the revised optimal point this gives a revised contribution of C = (50 × 4.222…) + (40 × 3.888…) = $366.67.

The increase of $6.67 ($366.67 – $360) is the shadow price for cutting time per hour. This represents the premium that the firm would be willing to pay for each extra hour of cutting time. The current cost is $10 per hour and therefore the maximum price that would be paid for an extra hour of cutting time is $16.67.

Note: A similar calculation can be done for assembly time giving a shadow price of $2.50 per hour.

Chapter

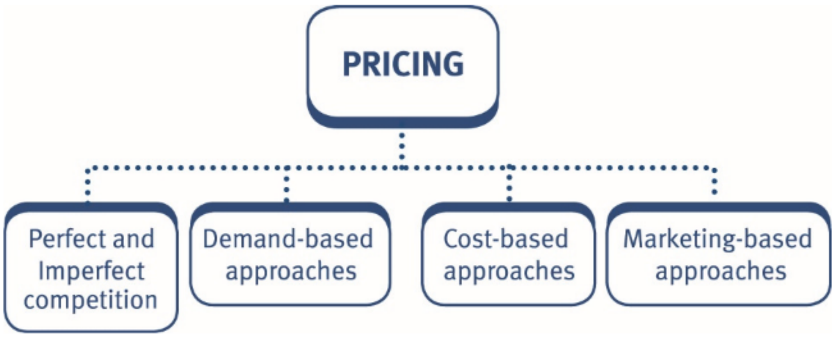
7

Pricing

Chapter learning objectives

Upon completion of this chapter you will be able to:

- Explain the factors that influence the pricing of a product or service.
- Calculate and explain the price elasticity of demand.
- Derive and manipulate a straight line demand equation. Derive an equation for the total cost function (including volume-based discounts).
- Calculate the optimum selling price and quantity for a product, equating marginal cost and marginal revenue.
- Evaluate a decision to increase production and sales levels, considering incremental costs, incremental revenues and other factors.
- Determine prices and output levels for profit maximisation using the demand-based approach to pricing (both tabular and algebraic methods).
- Explain different price strategies, including:
  - (i) All forms of cost-plus
  - (ii) Skimming
  - (iii) Penetration
  - (iv) Complementary product
  - (v) Product-line
  - (vi) Volume discounting
  - (vii) Discrimination
  - (viii) Relevant cost.
- Calculate a price from a given strategy using cost-plus and relevant cost.



1 Introduction

Pricing is important because:

- It makes a vital contribution to profit maximisation – the overriding aim of most businesses.
- Businesses make profits by selling goods and services at a price higher than their cost.
- The amount that they are able to sell will often be determined by the price charged for the goods and services.

2 Different types of market structures

The price that a business can charge for its products or services will be determined by the market in which it operates.

In a **perfectly competitive** market, every buyer or seller is a 'price taker', and no participant influences the price of the product it buys or sells. Other characteristics of a perfectly competitive market include:

- **Zero entry/Exit barriers** – It is relatively easy to enter or exit as a business in a perfectly competitive market.
- **Perfect Information** – Prices and quality of products are assumed to be known to all consumers and producers.
- **Companies aim to maximise profits** – Firms aim to sell where marginal costs meet marginal revenue, where they generate the most profit.
- **Homogeneous products** – The characteristics of any given market good or service do not vary across suppliers.

Imperfect competition refers to the market structure that does not meet the conditions of perfect competition. Its forms include:

- **Monopoly,** in which there is only one seller of a good. The seller dominates many buyers and can use its market power to set a profit-maximising price. Microsoft is usually considered a monopoly.
- **Oligopoly,** in which a few companies dominate the market and are inter-dependent: firms must take into account likely reactions of their rivals to any change in price, output or forms of non-price competition. For example, in the UK, four companies (Tesco, Asda, Sainsbury's and Morrisons) share about 70% of the grocery market (as per January 2022 figures).
- **Monopolistic competition,** in which products are similar, but not identical. There are many producers ('price setters') and many consumers in a given market, but no business has total control over the market price.

Illustration 1 – Monopolistic competition

For example, there are many different brands of soap on the market today. Each brand of soap is similar, because it is designed to get the user clean; however, each soap product tries to differentiate itself from the competition to attract consumers. One soap might claim that it leaves you with soft skin, while another that it has a clean, fresh scent. Each participant in this market structure has some control over pricing, which means it can alter the selling price as long as consumers are still willing to buy its product at the new price. If one product is priced at twice the amount of similar products on the market, chances are most consumers will avoid buying the more expensive product and buy the competitors' products instead. Monopolistic products are typically found in retailing businesses. Some examples of monopolistic products and/or services are shampoo products, extermination services, oil changes, toothpaste, and fast-food restaurants.

3 Three broad approaches to pricing

Pricing decisions may be separated into three broad approaches:

(1) Demand-based approaches

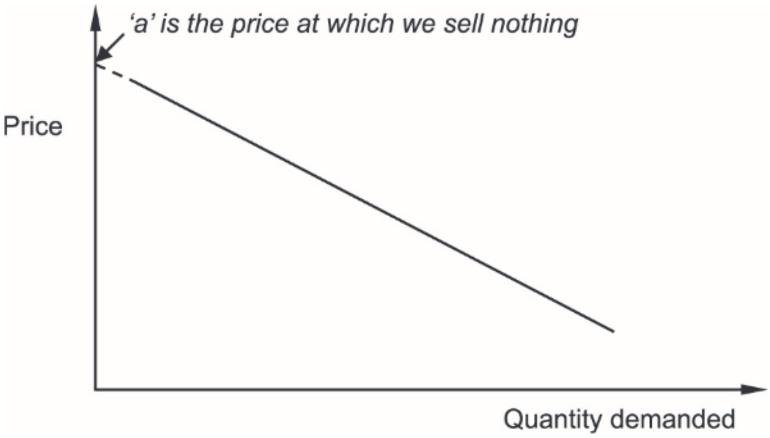
(2) Cost-based approaches

(3) Marketing-based approaches.

4 Demand-based approaches (The Economists' viewpoint)

Most firms recognise that there exists a relationship between the selling price of their product or service and the demand. By investigating and analysing this relationship it is possible, in theory, to establish an optimum price, i.e. a price that will maximise profits.

This relationship can often be described by an inverse, linear relationship:



Note: "a" can also be viewed as the theoretical maximum possible price that could be charged before demand fell to zero.

There are two methods of solution to problems investigating the relationship between price and demand: the algebraic approach, and the tabular approach.

5 The algebraic approach

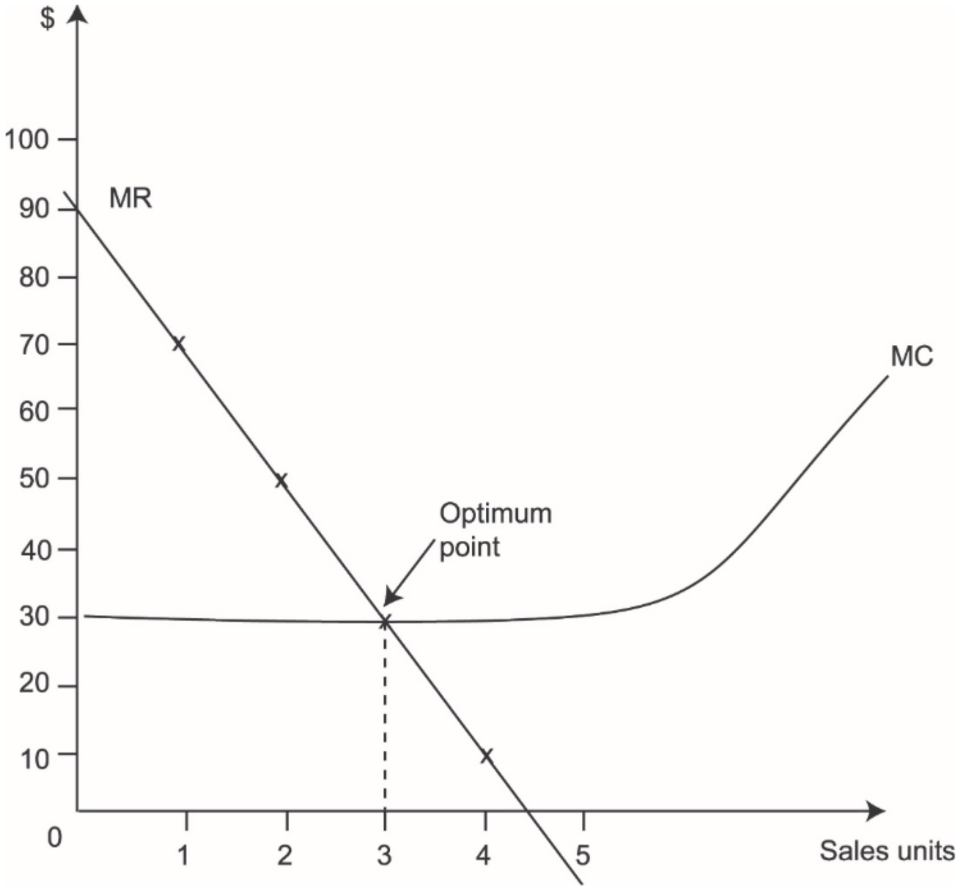
Economic theory states that the monopolist maximises profit when Marginal cost = Marginal revenue.

Illustration 2 – The MR= MC

Marginal revenue is the additional revenue from selling one extra unit, for example:

Quantity	Price	Revenue	Marginal revenue
1	$70	$70	$70
2	$60	$120	$50
3	$50	$150	$30
4	$40	$160	$10
5	$30	$150	$(10)

Marginal revenue is the additional revenue from selling one extra unit, for example:



The optimum price is $50. At output less than Q = 3, the extra cost of making a unit is less than the extra revenue from selling it – so it is worth selling it.

At output greater than Q = 3, the extra costs of making a unit exceed the revenue from selling it.

6 Procedure for establishing the optimum price of a product

This is a general set of rules that can be applied to most questions involving algebra and pricing.

(1) Establish the linear relationship between price (P) and quantity demanded (Q). The equation will take the form:

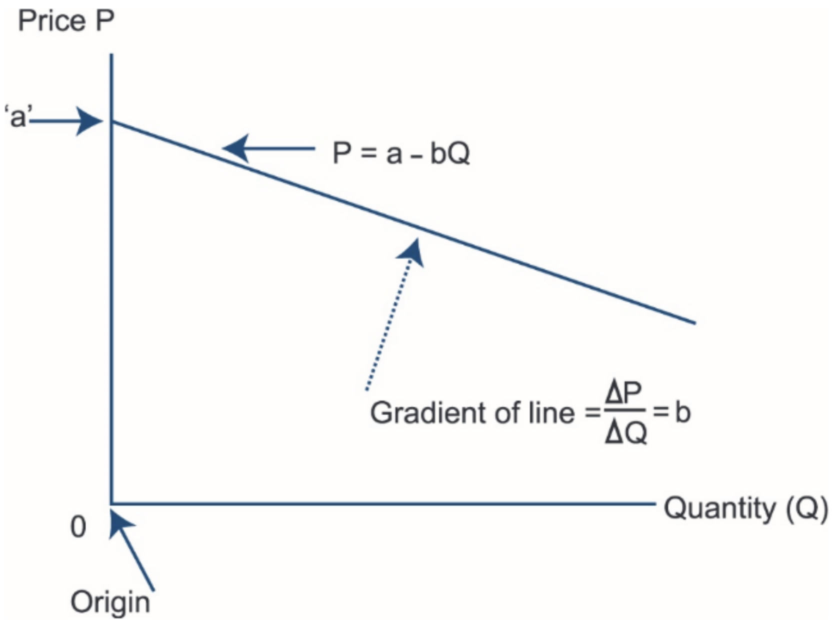
$$P = a - bQ$$

where

- 'a' is the intercept – here the maximum theoretical price at which demand will fall to zero
- 'b' is the gradient of the line – here the amount the price has to change to change the demand by one unit.

Since, as the price of a product increases, the quantity demanded will decrease; and the demand increases when the price drops, the elasticity 'b' has a negative value, but it is usual to ignore the minus sign.

The equation of a straight line P= a – bQ can be used to show the demand for a product at a given price:



Note: 'b' is always negative because of the inverse relationship between price and quantity.

(2) Double the gradient to find the marginal revenue: **MR = a − 2bQ**.

(3) Establish the **marginal cost MC**. This will simply be the variable cost per unit.

(4) To maximise profit, **equate MC and MR** and solve to find Q.

(5) Substitute this value of Q into the price equation to find the optimum price.

(6) It may be necessary to calculate the maximum profit.

The price elasticity of demand

When a business proposes to change the price of a product or service the key question is: 'to what degree will demand be affected?

Calculation

Price elasticity measures how responsive demand is to a change in price.

The price elasticity of demand measures the proportional or percentage change in demand as a result of a corresponding proportional or percentage change in price.

It can be calculated as follows:

$$\text{Price elasticity of demand} = \frac{\text{Change in quantity demanded, as a percentage of demand}}{\text{Change in price, as a percentage of the price}}$$

Example: assume that the sales of a retailer fall from 20 per day to 12 per day when the price of a chocolate bar goes up from 40c to 60c. The price elasticity can be calculated as follows: %change in price = (increase in price of 20/original price of 40) × 100 = +50%

%change in demand = (decrease in demand of – 8/original demand of 20) × 100 = – 40%

PED = – 40/+50 = – 0.8

The negative sign should be ignored in the PED calculation. Therefore the **PED = 0.8**.

Interpretation of PED

Elastic demand

If the % change in demand > the % change in price, then price elasticity > 1.

Demand is ‘elastic’, i.e. very responsive to changes in price.

- Total revenue increases when price is reduced.
- Total revenue decreases when price is increased.

Therefore, price increases are not recommended but price cuts are recommended.

Inelastic demand

If the % change in demand < the % change in price, then price elasticity < 1.

Demand is ‘inelastic’, i.e. not very responsive to changes in price.

- Total revenue decreases when price is reduced.
- Total revenue increases when price is increased.

Therefore, price increases are recommended but price cuts are not recommended.

Additional example on straight-line demand equation

(a) Find the linear relationship between price (P) and the quantity demanded (Q) in relation to the following sales and demand data:

- Selling price of \$300 = sales of 500 units per month
- Selling price of \$330 = sales of 400 units per month.

(b) Using the price equation in (a) and assuming the variable cost per unit is \$90, calculate the optimum price and output.

(c) Calculate the maximum contribution.

Solution

(a)

- P = a – bQ
- b (gradient) = (330 – 300) ÷ (400 – 500) = – 0.3
- remembering that price (P) = 300 when 500 units are sold and substituting 0.3 for b
- 300 = a – (0.3 × 500)
- 300 = a – 150
- a = 300 + 150 = 450
- So the linear relationship (or demand function equation) is: P = 450 – 0.3Q.

(b) MR = 450 – 0.6Q

MC = VC so equating MR = MC: 90 = 450 – 0.6Q So Q = 600

And substituting Q into Price function, P = \$270

(c) Contribution per unit = \$270 – \$90 = \$180

Total contribution = \$180 × 600 units = \$108,000

Note that if there were fixed costs in the question, and the examiner asked for the maximum **profit**, these fixed costs would need to be deducted from the maximum contribution.

Test your understanding 1

Find the linear relationship between price (P) and the quantity demanded (Q), i.e. find the straight-line demand equation, in relation to the following sales and demand data:

- Selling price of $200 = sales of 1,000 units per month.
- Selling price of $220 = sales of 950 units per month.

Required:

(a) Use this equation to predict the quantity demanded per month if the selling price is $300.

(b) Using the price equation in (a) and assuming the variable cost per unit is $100, calculate the optimum price and output.

(c) Calculate the maximum contribution.

Test your understanding 2

The total fixed costs per annum for a company that makes one product are $100,000, and a variable cost of $64 is incurred for each additional unit produced and sold over a very large range of outputs.

The current selling price for the product is $160. At this price, 2,000 units are demanded per annum.

It is estimated that for each successive increase in price of $5 annual demand will be reduced by 50 units. Alternatively, for each $5 reduction in price, demand will increase by $50 units.

Required:

(a) Calculate the optimum output and price, assuming that if prices are set within each $5 range there will be a proportionate change in demand.

(b) Calculate the maximum profit.

7 The tabular approach

A tabular approach to price setting involves different prices and volumes of sales being presented in a table.

When data in the exam is given in tabular form and there is no indication about the demand function, and/or when there is no simple linear relationship between output and profit – the tabular approach is likely to be the best to define optimum profit and the associated selling price.

Then, it makes sense to calculate the profit for each price and quantity combination, and finally select the price at which the level of profit is maximised.

Illustration 3 – Tabular approach

XYZ Ltd is a car manufacturer introducing a new type of car in a market where there is imperfect competition, so that to sell more units of output, it must reduce the sales price of all the units it sells. The following data is available for prices, and costs (all in $000):

Price per unit	Demand/output units	Total cost
50.00	1	44.00
47.00	2	56.00
44.00	3	71.00
41.00	4	85.00
38.00	5	95.00
35.00	6	110.00
32.00	7	122.00
29.00	8	135.00
26.00	9	145.00

Required:

Complete the table below to determine the output level and price at which the organisation would maximise its profits.

Price per unit	Demand/output units	Total revenue	MR	Total cost	MC	Profit
50.00	1					
47.00	2					
44.00	3					
41.00	4					
38.00	5					
35.00	6					
32.00	7					
29.00	8					
26.00	9					

Solution

Price per unit	Demand/ output units	Total revenue	MR	Total cost	MC	Profit
50.00	1	50.00	50.00	44.00	44.00	6.00
47.00	2	94.00	44.00	56.00	12.00	38.00
44.00	3	132.00	38.00	71.00	15.00	61.00
41.00	4	164.00	32.00	85.00	14.00	79.00
38.00	5	190.00	26.00	95.00	10.00	95.00
35.00	6	210.00	20.00	110.00	15.00	100.00
32.00	7	224.00	14.00	122.00	12.00	102.00
29.00	8	232.00	8.00	135.00	13.00	97.00
26.00	9	234.00	2.00	145.00	10.00	89.00

As the price per unit declines, so demand expands. Total revenue rises, but at a decreasing rate as shown by the column showing marginal revenue.

Profit increases every time the level of output increases, because the marginal revenue from selling units is greater than the marginal cost of producing them.

However, once marginal cost is greater than marginal revenue (at 8 units in our example), total profits start to fall.

The profit is maximised at 7 units of output and a price of $32,000, when MR is most nearly equal to MC.

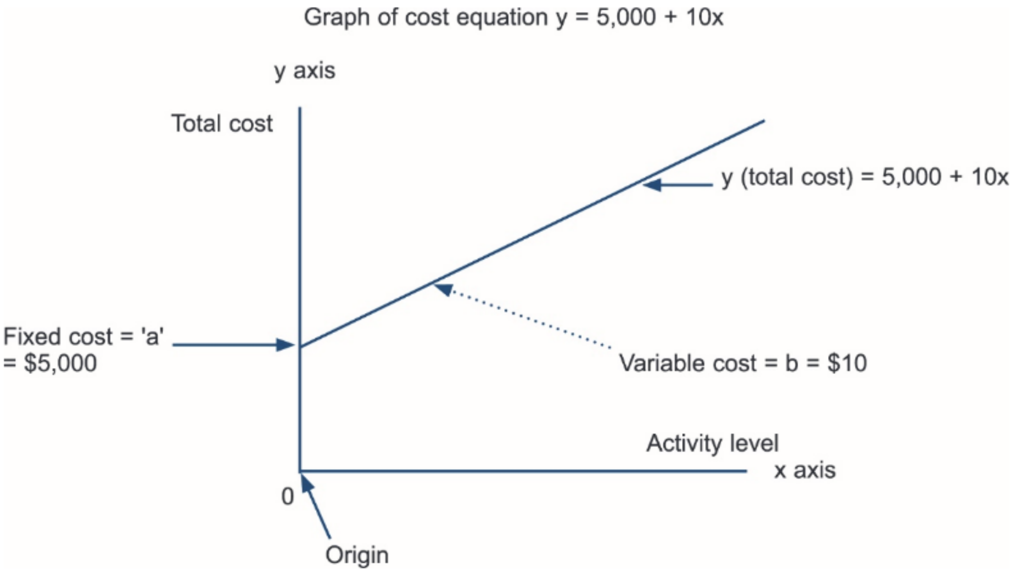
8 Equation for the total cost function

Cost equations are derived from historical cost data. Once a cost equation has been established (using methods such as the high/low method which will be revised later in the course) it can be used to estimate future costs. In the exam, cost functions will be linear:

$y = a + bx$

- ‘a’ is the fixed cost per period (the intercept)
- ‘b’ is the variable cost per unit (the gradient)
- ‘x’ is the activity level (the independent variable)
- ‘y’ is the total cost = fixed cost + variable cost (the dependent variable).

Suppose a cost has a cost equation of y = \$5,000 + 10x, this can be shown graphically as follows:



Additional example on the total cost function

Consider the linear function y = 1,488 + 20x and answer the following questions.

(a) The line would cross the y axis at the point

(b) The gradient of the line is

(c) The independent variable is

(d) The dependent variable is

Solution

(a)	The line would cross the y axis at the point	1,488
(b)	The gradient of the line is	20
(c)	The independent variable is	x
(d)	The dependent variable is	y

9 Cost equations including volume-based discounts

Suppliers often offer discounts to encourage the purchase of increased volumes.

Where volume-based discounts are offered a total cost equation can be derived for each volume range.

Additional example on volume-based discounts

You are given the following cost data:

Fixed costs	\$250,000.
Variable costs	\$6 per unit up to 5,000 units. 10% discount on all units purchased over 5,000 units.

Required:

Derive equations for the total cost function.

Solution

$y = 250,000 + 6x$ for $x \leq 5,000$.

$y = 250,000 + 5.4x$ for $x > 5,000$.

Test your understanding 3

- Fixed costs \$100,000.
- Variable costs per unit \$5 for volumes up to 1,000 units.
- Volumes above 1,000 units receive 5% discount on all units.

Required:

Derive the two equations for the total cost function.

10 Increasing sales and production levels

When an opportunity to increase sales and production levels arises in a business the key question to answer is:

- will the increased contribution (sales less variable costs) generated by the increased sales exceed any additional fixed costs that will be incurred as a result of the increased sales level?

If the answer is 'yes' the opportunity should normally be pursued.

Test your understanding 4

An opportunity arises to increase sales by 10,000 units:

- Selling price of additional units = \$10
- Variable cost of additional units = \$6
- Fixed costs will increase by = \$50,000

Required:

Should the opportunity be accepted?

Additional example on increasing volumes

A company produces and sells one product and its forecast for the next financial year is as follows:

	$000	$000
Sales 100,000 units @ $8		800
Variable costs:		
Material	300	
Labour	200	
		500
Contribution ($3 per unit)		300
Fixed costs		150
Net profit		150

In an attempt to increase net profit, two proposals have been put forward:

(a) To launch an advertising campaign costing $14,000. This will increase the sales to 150,000 units, although the price will have to be reduced to $7.

(b) To produce some components at present purchased from suppliers. This will reduce material costs by 20% but will increase fixed costs by $72,000.

Required:

Decide whether these proposals should be pursued.

Solution

Proposal (a) will increase the sales revenue but the increase in costs will be greater:

	$000
Sales (150,000 @ $7)	1,050
Variable costs (150,000 @ $5)	750
Contribution ($2 per unit)	300
Fixed costs plus advertising	164
Net profit	136

This is lower than the current forecast.

Proposal (b)

- reduces variable costs by $60,000 ($300,000 × 20%)
- but increases fixed costs by $72,000 and is therefore not to be recommended unless the total volume increases as a result of the policy (e.g. if the supply of the components were previously a limiting factor).

Conclusion

Neither proposal should be accepted.

11 Cost plus pricing

Many businesses adopt simple cost-plus pricing techniques:

- Price = cost per unit + chosen margin or mark-up.
- There is a difference between a mark-up and a margin.
- A mark-up is the profit expressed as a percentage of cost (cost is 100%).
- A margin is the profit expressed as a percentage of the sales price (sales is 100%).

Which cost to use?

When using cost-plus pricing the following options are available:

- **Actual or standard cost**

  The advantage of using standard costing is that prices can be set in advance and fixed for the period concerned. This makes marketing simpler and may attract customers who value knowing exactly how much they will pay. The main disadvantage is that if significant variances occur, then the price may have been set too low and a loss ensues.

  The main advantage of using actual costs is that a profit is guaranteed. However, there is less incentive for the supplier to control costs as inefficiencies can be passed on to customers. Such a contract may discourage some customers from dealing with the firm concerned. Examples where actual costs are used include large military contracts (where cost overruns often become a matter of political debate), tradesmen (e.g. builders) and car repairs, where the mark-up is incorporated into the hourly labour rate used by the garage.

- **Marginal or full cost**

  The use of marginal cost is simpler as there is no need for the absorption of fixed overheads and could be argued to be more consistent with the use of contribution in decision making. The main difficulty lies in setting an appropriate margin or mark-up as this will need to ensure that fixed costs are covered. In practice the danger is often that prices are set too low. Marginal costing is particularly useful in short-term decisions concerning the use of excess capacity or one off contracts.

The use of full cost ensures that all costs are incorporated into the pricing decision, so should ensure a profit is made, provided the target volume is achieved. However, to calculate the fixed cost per unit an assumption must be made concerning sales volumes, which in turn depend on the price, which depends on the cost per unit. A further criticism is that the method of absorbing overheads is somewhat arbitrary, so the prices obtained may not be very realistic when compared with what customers are willing to pay.

- **Relevant costs**

  The principles of relevant costing were met in MA and will be reviewed in more detail in a later chapter.

  Relevant costs can be used to arrive at a minimum tender price for a one-off tender or contract. The minimum price should be equal to the total of all of the relevant cash flows.

  The use of relevant costs is only suitable for a one-off decision since:

  – fixed costs may become relevant in the long run

  – there are problems estimating incremental cash flows

  – there is a conflict between accounting measures such as profit and this approach.

Example of cost-plus pricing

When using a cost-plus pricing strategy a business should work through a step by step approach. For example:

Step 1: Establish the cost per unit. For example, if full cost is used this may be:

• raw materials	$40 per unit
• variable production costs	$40 per unit
• fixed costs based on planned volumes	$20 per unit
• total cost	$100 per unit

Step 2: Add the target profit to arrive at the selling price. For example:

- 20% mark-up = selling price of $120 per unit
- 20% sales margin = selling price of $125 per unit.

Step 3: Consider how realistic the target profit is. This will depend upon:

- accurate knowledge of costs
- the selling price arrived at being one which customers are prepared to pay
- selling the planned volume of goods.

Advantages and disadvantages of cost-plus pricing

Advantages of cost-plus pricing	Disadvantages of cost-plus pricing
• Widely used and accepted. • Simple to calculate if costs are known. • Selling price decision may be delegated to junior management. • Justification for price increases. • May encourage price stability – if all competitors have similar cost structures and use similar mark-up.	• Ignores the economic relationship between price and demand. • No attempt to establish optimum price. • Different absorption methods give rise to different costs and hence different selling prices. • Does not guarantee profit – if sales volumes are low fixed costs may not be recovered. • Must decide whether to use full cost, manufacturing cost or marginal cost. • This structured method fails to recognise the manager's need for flexibility in pricing. • Circular reasoning – for example, a price increase will reduce volume, thus increasing unit costs, resulting in pressure to increase the price further.

Test your understanding 5 – Greenfields

(1) Greenfields Ltd manufactures three products, W, X and Y. Each product uses the same materials and the same type of direct labour but in different quantities. The company currently uses a full cost-plus basis to determine the selling price of its products. This is based on full cost, using an overhead absorption rate per direct labour hour.

The direct costs of the three products are shown below:

	Product W	**Product X**	**Product Y**
Budgeted annual production, in units	15,000	24,000	20,000
Direct materials ($ per unit)	$35	$45	$30
Direct labour ($10 per hour)	$40	$30	$50

In addition to the above direct costs, Greenfields incurs annual indirect production costs of $1,044,000.

What is the full cost per unit of each product, using Greenfields's current method of absorption costing?

A $18 for W, $75 for X and $22.50 for Y

B $75 for W, $75 for X and $100.50 for Y

C $93 for W, $88.50 for X and $102.50 for Y

D $93 for W, $90.50 for X and $102.50 for Y

(2) An analysis of the company's indirect production costs shows the following:

	$	**Cost drivers**
Material ordering costs	220,000	Number of supplier orders
General facility costs	824,000	Number of labour hours

The following additional data relate to each product:

	Product W	**Product X**	**Product Y**
Suppliers orders per line of products	120	180	100

What is the full cost per unit of each product, using ABC?

A $14.21 for W, $10.66 for X and $17.76 for Y

B $93.61 for W, $99.16 for X and $100.50 for Y

C $93.61 for W, $89.79 for X and $100.51 for Y

D $107.21 for W, $99.16 for X and $120.25 for Y

(3) The company currently uses a full cost plus basis to determine the selling price of its products.

Which of the following statements regarding the current full cost-plus pricing approach strategy are correct?

(1) The use of absorption costing means that the price is dependent at least in part on the method used to absorb the costs into each cost unit.

(2) The use of absorption costing suggests that this is the cost of the individual item whereas, in fact, it includes costs that would continue to be incurred if the item were not produced.

(3) A manager may reject a sale because the customer is only prepared to pay a price which is less than the absorption cost.

(4) Full cost-plus pricing requires that the profit mark-up applied by a company is fixed.

A Statements (2) and (4)

B Statements (1), (2) and (3)

C Statements (1), (3) and (4)

D Statements (1), (2), (3) and (4)

(4) The managing director is concerned that the company may be losing sales because of its approach to setting prices. They think that a marginal cost-plus costing approach may be more appropriate, particularly since the workforce is guaranteed a minimum weekly wage and has a three month notice period.

Which of the following statements regarding a marginal cost-plus pricing approach strategy are correct?

(1) The use of marginal costing identifies the variable cost of the item produced and thus provides a clear indication of the maximum price that should be charged so as to avoid a negative contribution.

(2) A marginal cost-plus approach may mean that managers are persuaded to sell items at too low a price, so that the contribution earned is insufficient to cover the fixed costs of the business.

(3) It is very difficult to increase the price for a subsequent sale of the same item to the same customer, so the company may find it difficult to break out of the low price arena once they have entered it.

(4) Marginal cost-plus pricing is easier where there is a readily identifiable variable cost.

A Statements (1) and (2)

B Statements (3) and (4)

C Statements (1), (3) and (4)

D Statements (2), (3) and (4)

(5) **Which of the following statements regarding the use of ABC in pricing decisions are correct?**

(1) The management of Greenfields can use the information provided by the activity-based costing approach to identify potential cost savings by changing the method of operation within the company.

(2) It may be appropriate to consider investing in new machines to automate production processes and increase the number of labour hours.

(3) The effect of activity-based costing is often to identify costs as being more controllable because their cause has now been identified.

(4) While some facility costs will remain and are truly fixed as they are not driven by any particular future activity, many of the other costs will now become variable depending on the number of times an activity is performed.

A Only statements (1) and (2)

B Only statements (2), (3) and (4)

C Only statements (1), (3) and (4)

D All statements

Customer based pricing – the marketer's approach

Customer-based pricing reflects customers' perceptions of the benefits they will enjoy from purchasing the product, e.g. convenience, status. The product is priced to reflect these benefits.

This approach has regard to costs but reflects a belief that the greater understanding you have of your customer the better placed you are to price the product.

Illustration 4 – Customer-based pricing

On a remote beach in a hot country, the offer of food and drink to tourists on the beach will be perceived by them as being of significant benefit and they are likely to be prepared to pay a significant amount in excess of cost.

Competition-based pricing

Competition-based pricing means setting a price based upon the prices of competing products.

Competing products can be classified as:

- The same type of product which is not easily distinguished from one's own products. For example, petrol sold at two competing petrol stations.
  - price changes by competitors will have a material impact.
- Substitute products which are different products but fulfil the same need, e.g. you may buy ice cream instead of soft drinks on a hot day.
  - impact of price changes will depend on relative price/performance of substitute.

Test your understanding 6

Of the three approaches to pricing discussed above:

- cost-based
- customer-based
- competition-based.

Which is the least likely to maximise profits and why?

12 Different pricing strategies

There are a number of different pricing strategies available to a business:

- Cost-plus pricing
- Market-skimming
- Penetration pricing
- Complementary product pricing
- Product-line pricing
- Volume discounting
- Price discrimination
- Relevant cost pricing.

Cost-plus pricing was covered earlier. The other strategies will now be reviewed in turn.

13 Market-skimming pricing strategy

Market skimming involves charging high prices when a product is first launched in order to maximise short-term profitability. Initially high prices may be charged to take advantage of the novelty appeal of a new product when demand is initially inelastic.

Once the market becomes saturated the price can be reduced to attract that part of the market that has not been exploited.

Conditions suitable for a market-skimming strategy

- Where the product is new and different and has little direct competition. This is the most common reason for using a market-skimming strategy.
- Where products have a short life cycle, and there is a need to recover their development costs quickly and make a profit.
- Where the strength of demand and the sensitivity of demand to price are unknown. From a psychological point of view it is far better to begin with a high price, which can then be lowered if the demand for the product appears to be more price sensitive than at first thought.
- A firm with liquidity problems may use market-skimming in order to generate high cash flows early on.

With high prices being charged potential competitors will be tempted to enter the market. For skimming to be sustained one or more significant barriers to entry must be present to deter these potential competitors. For example, patent protection, strong brand loyalty.

Test your understanding 7

What products may be priced using a market-skimming strategy?

14 Penetration pricing strategy

- **Penetration pricing** is the charging of low prices when a new product is initially launched in order to gain rapid acceptance of the product.
- Once market share is achieved, prices are increased.
- It is an alternative to market skimming when launching a new product.

Circumstances which favour a penetration policy

- If the firm wishes to increase market share.
- A firm wishes to discourage new entrants from entering the market.
- If there are significant economies of scale to be achieved from high volume output, and so a quick penetration into the market is desirable.
- If demand is highly elastic and so would respond well to low prices.

Illustration 5 – Penetration pricing strategy

Many new foods introduce themselves to the market with a penetration pricing strategy. Some businesses even give packages of new products away by, for example, sponsoring events and providing sample packs to attendees. In one notable such example, Crispos Co introduced Crunchies Crisps to the market in 2019. The brand was a direct competitor to the well-established Sprongles line of crisps.

To draw more business, the company offered the crisps at a steep discount of $0.69 per bag. This earned the brand prominent display locations at many retailers. When the crisps had fully penetrated the market, the price quickly rose to well above $1.

15 Complementary-product pricing

A **complementary product** is one that is normally used with another product. An example is razors and razor blades – if sales of razors increase more razor blades will also be bought.

Other examples of complementary products are:

- game consoles and associated games
- printers and printer cartridges.

Complementary goods provide suppliers with additional power over the consumer.

Illustration 6 – What is complementary-product pricing?

A complementary-product pricing strategy can take two forms:

- The major product (e.g. a printer or a camera) is priced at a relatively low figure – to encourage the purchase and lock the consumer into subsequent purchases of relatively high price consumables (e.g. printer cartridges or memory cards). This is the most common form.
- The major product (e.g. membership of a fashionable sports or golf club) is priced at a relatively high figure – to create a barrier to entry and exit and the consumer is locked into subsequent purchases of relatively low-price facilities (e.g. court fees or green fees).

16 Product-line pricing strategy

A product line is a range of products that are related to one another.

Product line pricing occurs when setting the price steps between various products in a product line, based on:

- Cost differences between the products
- Customer evaluations of different features
- Competitors prices.

In other words, product line pricing occurs when a company must decide the price differences between the upgrades of a product or service.

Illustration 7 – Product-line pricing strategy

A basic car wash may be shown as one price, a super wash with wash and wax will cost a little more, and a full-service premium wash will be the most expensive.

17 Volume-discounting pricing strategy

Volume discounting means offering customers a lower price per unit if they purchase a particular quantity of a product.

It takes two main forms:

- Quantity discounts – for customers that order large quantities.
- Cumulative quantity discounts – the discount increases as the cumulative total ordered increases. This may appeal to those who do not wish to place large individual orders but who purchase large quantities over time.

Benefits to the business of using a volume discounting strategy

- Increased customer loyalty – cumulative quantity discounts 'lock in' the customer since further purchases can be made at a lower cost per unit.
- Attracting new customers – an exceptional level of discount can be offered to new customers on a one-off basis, enabling the supplier to 'get their feet in the door'.
- Lower sales processing costs – an increased proportion of their sales take the form of bulk orders.
- Lower purchasing costs – high sales volumes enable the business to enjoy discounts from their suppliers, creating a virtuous circle.
- Discounts help to sell items that are bought primarily on price.
- Clearance of surplus stock or unpopular item through the use of discounts.
- Discounts can be geared to particular off-peak periods.

Conditions suitable for a volume-discounting pricing strategy

- Sales margin is substantial allowing profits to be made even after discounting.
- The product is bought on price and it is difficult to distinguish it from competing products.
- Products with a limited shelf life (for example, fashion items) may be discounted to shift them.

Different pricing strategies

Situation	**Pricing strategy**
• Product is new and different (e.g. new electronic product). • 'Early adopters' are prepared to pay high prices to achieve ownership. • Significant barriers to entry exist (e.g. patent protection, high capital investment, or unusually strong brand loyalty) to deter competition – in order that skimming can be sustained. • The product has a short life cycle so there is a need to recover development costs and make a profit quickly. • The business has a liquidity problem and may be attracted by the high initial cash flows available in the early stages of a product's life. • Strength of demand and the sensitivity of demand to price are unknown. It is much easier to lower prices than to increase them.	Skimming
• The business wishes to discourage newcomers from entering the market. • The business wishes to shorten the initial period of the product's life cycle in order to enter the growth and maturity stages as quickly as possible. • There are significant economies of scale to be achieved from high-volume output, and so a quick penetration into the market is desirable in order to gain those unit cost reductions. • Demand is highly elastic and so would respond well to low prices.	Penetration

• A range of products is being marketed – the products within a product line are related but may vary in terms of style, colour, quality, etc. (e.g. dinner services, cutlery sets). • Consumers will tend to buy a number of items within the range and be prepared to pay a relatively high price for the less essential items in order to build up a matching set.	Product-line
• The sales margin is substantial, allowing good profits to be made even after significant discounting (e.g. consumer software products). • The product is traditionally bought on price – it is difficult to distinguish from competing products (e.g. car tyres). • Products with a limited shelf life (e.g. fashion items).	Volume discounting

18 Price-discrimination pricing strategy

A price-discrimination strategy is where a company sells the same product or services at different prices in different markets, for reasons not associated with costs.

Conditions required for a price-discrimination strategy

- The seller must have some degree of monopoly power, or the price will be driven down.
- Customers can be segregated into different markets.
- Customers cannot buy at the lower price in one market and sell at the higher price in the other market.
- Price discrimination strategies are particularly effective for services.
- There must be different price elasticities of demand in each market so that prices can be raised in one and lowered in the other to increase revenue.

Dangers of price-discrimination as a strategy

- A black market may develop allowing those in a lower priced segment to resell to those in a higher priced segment.
- Competitors join the market and undercut the firm's prices.
- Customers in the higher priced brackets look for alternatives and demand becomes more elastic over time.

Test your understanding 8

Which products or services lend themselves to a price-discrimination strategy?

Test your understanding 9 – Recap of pricing strategies

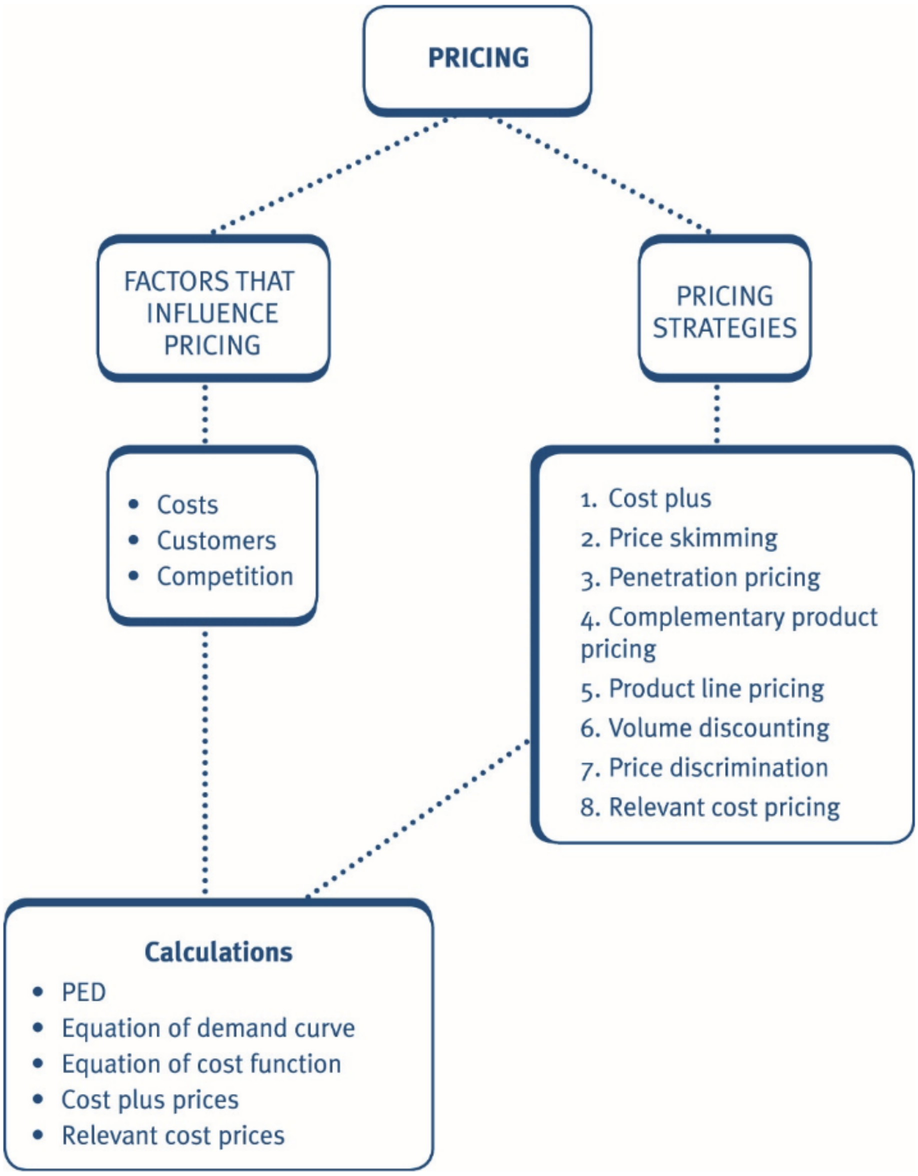
(1) Which pricing strategies are aimed at the start of the product life cycle?

(2) Which pricing strategies seek to attract sales by offering a product at a relatively low price?

(3) Which pricing strategies lure the customer in with a relatively low-priced product in order to lock the customer in to subsequent additional purchases of similar items that are relatively highly priced?

(4) Which pricing strategy is appropriate to items that are bought primarily on price.

19 Chapter summary



Test your understanding answers

Test your understanding 1

(a) **Step 1: Find the gradient, b**

The question provides us with two selling prices and the respective level of demand at these selling prices. Therefore, we can begin by calculating the gradient of the straight line, b.

b (gradient) = change in price/change in quantity

$= (220 - 200)/(950 - 1000) = -0.4$

Step 2: Calculate the intersect, a

Once the gradient is known the intersect can be found using either of the selling prices and demand levels given in the question.

For example, price (P) = 200 when 1000 units (Q) are sold and substituting – 0.4 for b

$200 = a - (0.4 \times 1{,}000)$

$200 = a - 400$

$a = 200 + 400 = 600$

Step 3: Straight-line demand equation

So the equation is: $P = 600 - 0.4Q$.

Step 4: Forecast the demand at a given selling price

At a price of \$300

$300 = 600 - 0.4Q$

$0.4Q = 300$

$Q = 300/0.4$

Quantity demanded (Q) = 750 units per month

(b) $MR = 600 - 0.8Q$

MC = VC so equating MR = MC: $100 = 600 - 0.8Q$

So $Q = 625$

And substituting Q into Price function, P = \$350

(c) Contribution per unit = \$350 – \$100 = \$250

Total contribution = \$250 × 625 units = \$156,250

Test your understanding 2

(a) Let Q = quantity produced/sold

Gradient 'b' =

$$b = \frac{\text{Change in price}}{\text{Change in quantity}} = \frac{\$5}{\$50}$$

b = – 0.1

Price = a – 0.1Q; $160 = a – 0.1 (2,000) therefore a = **$360**

P = $360 – 0.1Q

MR = $360 – 0.2Q

MC = $64

To maximise profit, MR = MC. Therefore, $360 – 0.2Q = $64

Q = (360 – 64) ÷ 0.2 = 1,480 units

P = 360 – 0.1 (1,480) = $212

(b)

Revenue = $212 × 1,480 = $313,760

Less Costs = ($64 × 1,480) + $100,000 = ($194,720)

Maximum profit = $119,040

Test your understanding 3

- Y = 100,000 + 5x for x ≤1,000
- Y = 100,000 + 4.75x for x >1,000.

Test your understanding 4

The effect of the increased sales would be to reduce net profits by $10,000.

- $100,000 increased sales ($10 × 10,000 units)
- $60,000 increased variable costs ($6 × 10,000 units) = $40,000 additional contribution
- less additional fixed costs of $50,000 = $10,000 reduction in net profit.

Based on this analysis, the opportunity should be rejected. However, other factors need to be considered such as:

- the impact on future sales beyond the current period
- the impact of rejection on customer goodwill
- whether the extra sales would help build the firm's brand.

Test your understanding 5 – Greenfields

(1) **C**

The full cost per unit includes all production costs, including a share of fixed overheads.

$$\text{OAR} = \frac{\text{Budgeted production overhead (\$1,044,000, per question)}}{\text{Activity level (Total number of labour hours)}}$$

$$\text{OAR} = \frac{\$1{,}044{,}000}{\text{232,000 labour hours (W1)}}$$

OAR = $4.50 per labour hour

	Product W	**Product X**	**Product Y**
Material costs per unit, as per question	$35	$45	$30
Labour costs per unit, as per question	$40	$30	$50
Fixed overhead cost per unit	$4.50 × 4 hours = $18	$4.50 × 3 hours = $13.50	$4.50 × 5 hours = $22.50
Total = full cost per unit	**$93**	**$88.50**	**$102.50**

(2) **C**

	Product W	**Product X**	**Product Y**
Material costs per unit, as per question	$35	$45	$30
Labour costs per unit, as per question	$40	$30	$50
Material ordering costs per unit (W2)	$4.40	$4.125	$2.75
General running costs per unit (W3)	$14.21	$10.655	$17.759
Total cost per unit using ABC	**$93.61**	**$89.79**	**$100.51**

(3) **B**

Statement (4) is not correct. The mark-up percentage does not have to be fixed: it may vary and be adjusted to reflect market conditions.

(4) **D**

All statements are correct, apart from statement (1), which should refer to the minimum (not the maximum) price: The use of marginal costing identifies the variable cost of the item produced and thus provides a clear indication of the **minimum** price that should be charged so as to avoid a negative contribution.

(5) **C**

Statement 2 is not correct. Investing in new machines would hopefully reduce the number of labour hours.

Workings

(W1)	**Product W**	**Product X**	**Product Y**
Direct labour hours per unit	4 hours	3 hours	5 hours
Total number of units	15,000 units	24,000 units	20,000 units
Total number of hours: 232,000 hours	60,000 hours	72,000 hours	100,000 hours

(W2)

The 'material ordering costs' activity will be associated with the number of supplier orders. There are (120 + 180 + 100) = 400 supplier orders in total.

$$\text{Cost per supplier order} = \frac{\$220{,}000}{400 \text{ orders}} = \$550 \text{ per supplier order}$$

	Product W	**Product X**	**Product Y**
Material ordering costs per unit	($550 per order × 120)/15,000 = $4.40 per unit	($550 per order × 180)/24,000 = $4.125 per unit	($550 per order × 100)/20,000 = $2.75 per unit

(W3)

The 'General running costs' activity will be associated with the number of labour hours.

$$\text{Cost per order} = \frac{\$824{,}000}{232{,}000 \text{ lab hours}} = \$3.551 \text{ per labour hour}$$

	Product W	**Product X**	**Product Y**
General running costs per unit @ $3.551 per labour hour	$14.21	$10.655	$17.759

Test your understanding 6

Customer-based and competition-based pricing are most likely to maximise profits since they take into account the behaviour of customers and competitors, as well as the need to recover costs or obtain a particular margin on sales. Cost-based pricing, in contrast, simply reflects the objective of cost recovery or achieving a margin on sales and ignores the potential to exploit the level of customers' interest in the product or the strength of the product in the marketplace relative to competitors.

Test your understanding 7

Market skimming is often used in relation to electronic products when a new range (e.g. smartphones) are first released onto the market at a high price.

The target is the 'early adopters' of such products; their price sensitivity is relatively low because their interest in the product is substantial or they have a stronger appreciation of the qualities offered by the product.

Test your understanding 8

Examples of price discrimination include:

- lower admission prices for children at certain sporting and entertainment events
- discounts for Senior Citizens in some pubs and restaurants
- concessionary rail fares for students
- lower admission prices for females at some nightclubs.

Test your understanding 9 – Recap of pricing strategies

(1) Skimming and the penetration-pricing strategies.

(2) Penetration and volume discounting rely substantially on relatively low-price offers; this is also true to a lesser extent of complementary and product line pricing strategies.

(3) Complementary and product-line pricing strategies.

(4) Volume discounting.

Chapter

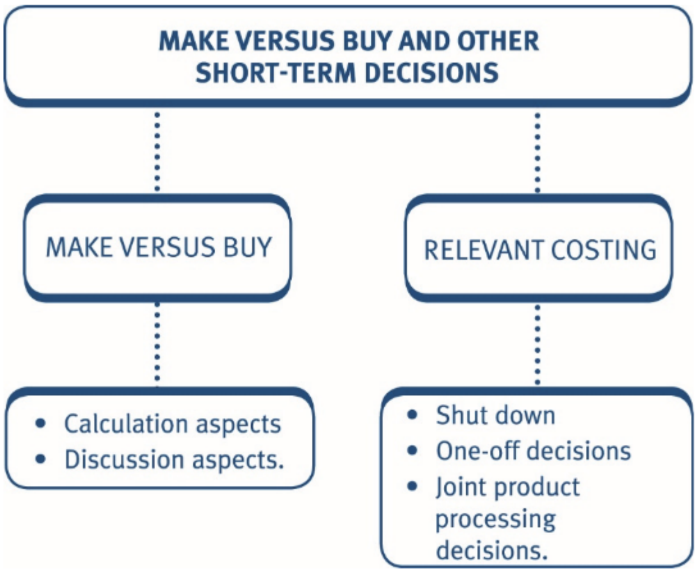
8

Relevant costing

Chapter learning objectives

Upon completion of this chapter, you will be able to:

- Explain the concept of relevant costing.
- Identify and calculate relevant costs for specific decision situations from given data.
- Explain and apply the concept of opportunity costs.
- Explain the issues surrounding make-or-buy and outsourcing decisions.
- Calculate and compare "make" costs with "buy-in" costs.
- Compare in-house costs and outsource costs of completing tasks and consider other issues surrounding this decision.
- Apply relevant costing principles in situations involving shut down, one-off contracts and the further processing of joint products.



1 Introduction

This chapter will focus on a number of short-term decisions that are typically made by a business:

- Make versus buy decisions
- Shut-down decisions
- One-off contract decisions
- Further processing decisions.

Each of these decisions is based on relevant costing principles. Therefore, a recap of relevant costing will be useful before looking at each of the decisions in turn.

2 Relevant costs and revenues

Decision making involves making a choice between two or more alternatives. When a business is making one of the short-term decisions mentioned it should only consider the relevant cash flows that arise as a result of this decision:

Cash position if accept proposal A

Relevant cash flow = A – B

Cash position if reject proposal B
(and do next best alternative instead)

A relevant cash flow is a 'future incremental cash flow'.

- **Future**

  Only future cash flows that occur as a result of the decision should be considered, e.g. any future costs or revenue.

  Sunk costs (i.e. costs that have already been incurred in the past) are not relevant to the decision, and should therefore be ignored – we cannot change the past.

- **Incremental**

  Only extra cash flows that occur as a result of the decision should be considered, e.g. extra costs or revenues.

  Fixed costs should be ignored unless there is an incremental fixed cost as a result of the decision.

  Committed costs (i.e. costs that are unavoidable in the future) are not affected by the decision and should therefore be ignored.

  Opportunity costs should be included – look at the next best alternative use of a resource.

- **Cash flows**

  Only cash items are relevant to the decision.

  For example, depreciation is not relevant since it is not a cash flow.

Test your understanding 1 – Relevant costs

Identify which of the following costs are relevant to the decisions specified:

(a) The salary to be paid to a market researcher who will oversee the development of a new product. This is a new post to be created especially for the new product but the $12,000 salary will be a fixed cost.

Is this cost relevant to the decision to proceed with the development of the product?

(b) The $2,500 additional monthly running costs of a new machine to be purchased to manufacture an established product. The new machine will reduce labour costs by $3,000 per month. Since the new machine will save on labour time, the fixed overhead to be absorbed by the product will also reduce by $100 per month, as overheads are absorbed on a labour hour basis.

Are these costs relevant to the decision to purchase the new machine?

(c) Office cleaning expenses of $125 for next month. The office is cleaned by contractors and the contract can be cancelled by giving one month’s notice.

Is this cost relevant to a decision to close the office?

(d) Expenses of $75 paid to the marketing manager. This was to reimburse the manager for the cost of travelling to meet a client with whom the company is currently negotiating a major contract.

Is this cost relevant to the decision to continue negotiations?

3 Opportunity cost

Opportunity cost is an important concept for decision-making purposes. It is the value of the best alternative that is foregone when a particular course of action is undertaken. It emphasises that decisions are concerned with choices and that by choosing one plan, there may well be sacrifices elsewhere in the business.

Opportunity costs

A new project requires the use of an existing machine that would otherwise be sold.

Information concerning the machine is as follows:

- Original purchase price = $20,000
- Current carrying value = $5,000
- Estimated current sales value = $4,000

Required:

What is the relevant cost (if any) if using the machine in the project?

Solution

- The original purchase price is sunk so is not relevant.
- The carrying value is a combination of the purchase price (sunk) and depreciation (not a cash flow) so is not relevant.
- By undertaking the project we miss out on the opportunity of selling the asset and thus have an opportunity cost of ($4,000).

Cash position if accept proposal	NIL
Cash position if reject proposal	
Receive (and do next best alternative instead)	$4,000

So relevant cash flow (cost) is the difference of $4,000. This is the amount foregone by going ahead with the project.

Test your understanding 2 – Opportunity cost

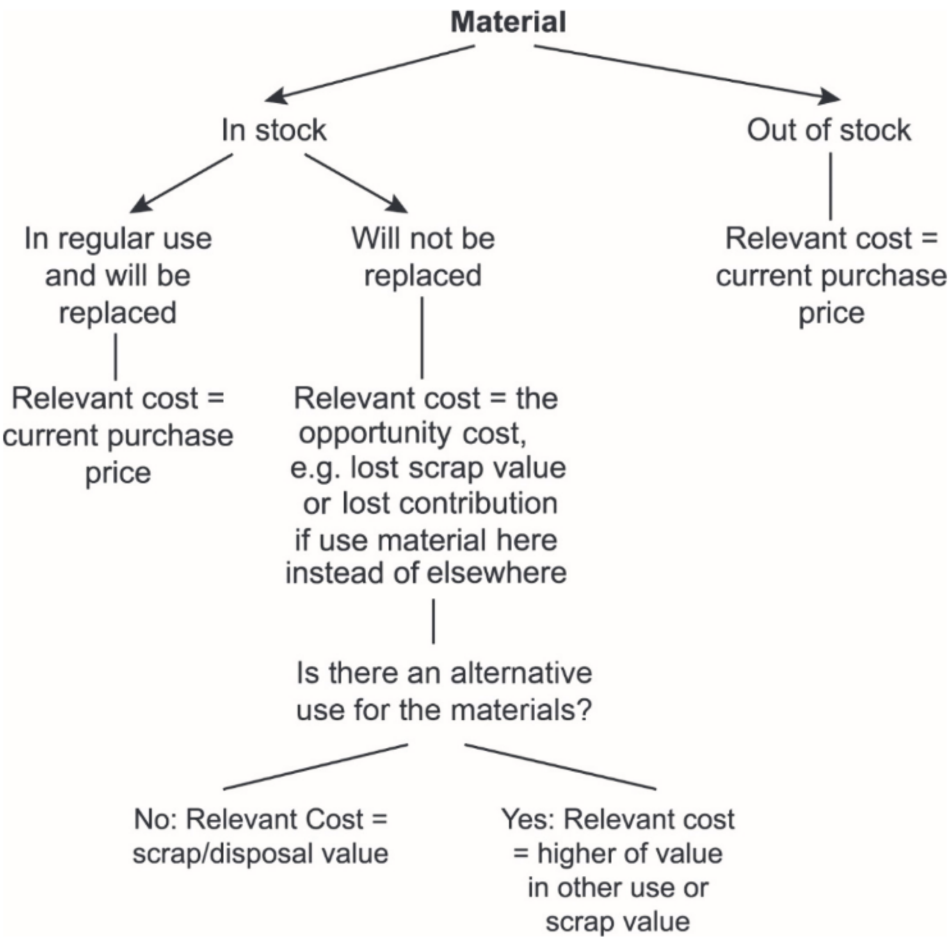
A company which manufactures and sells one single product is currently operating at 85% of full capacity, producing 102,000 units per month. The current total monthly costs of production amount to $330,000, of which $75,000 are fixed and are expected to remain unchanged for all levels of activity up to full capacity.

A new potential customer has expressed interest in taking regular monthly delivery of 12,000 units at a price of $2.80 per unit.

All existing production is sold each month at a price of $3.25 per unit. If the new business is accepted, existing sales are expected to fall by 2 units for every 15 units sold to the new customer.

What is the overall increase in monthly profit which would result from accepting the new business?

4 The relevant cost of materials

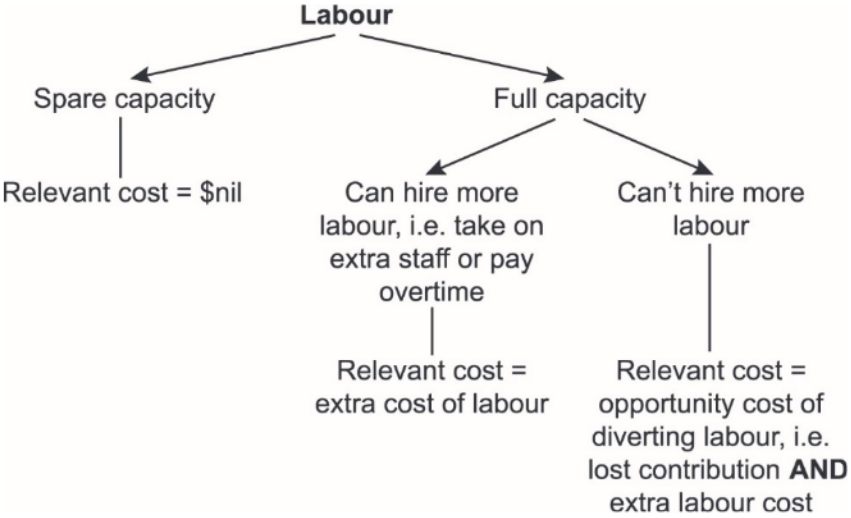

Material
In stock
Out of stock
In regular use and will be replaced
Will not be replaced
Relevant cost = current purchase price
Relevant cost = current purchase price
Relevant cost = the opportunity cost, e.g. lost scrap value or lost contribution if use material here instead of elsewhere
Is there an alternative use for the materials?
No: Relevant Cost = scrap/disposal value
Yes: Relevant cost = higher of value in other use or scrap value

Any historic cost given for materials is **always a sunk cost** and **never relevant** unless it happens to be the same as the current purchase price.

Note: The above diagram assumes that it is possible to buy more materials if required. This may not always be the case.

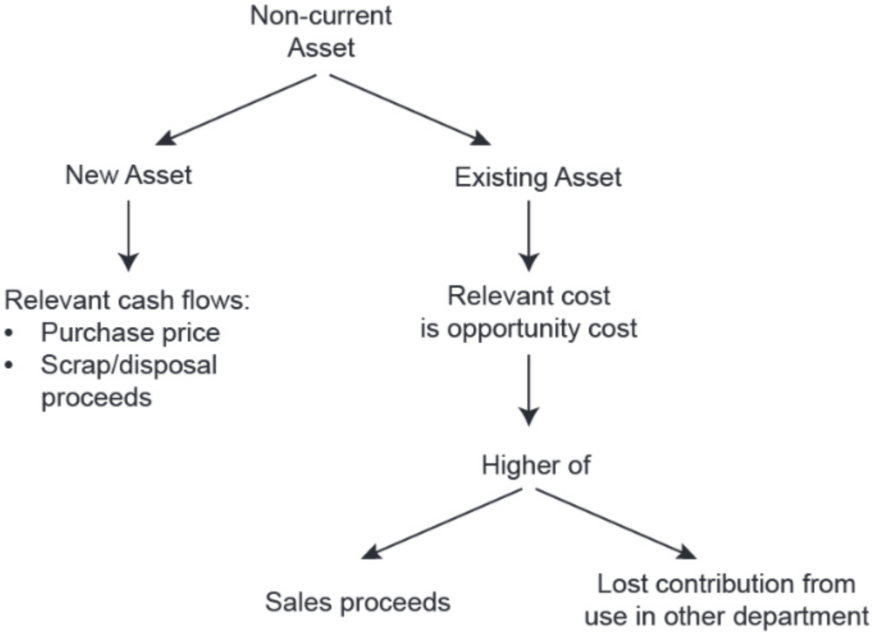
- If a material is in short supply, then the only way a proposal can be undertaken would be by denying another part of the organisation that resource.
- In this case the relevant cost = normal materials cost + lost contribution in the other department.

5 The relevant cost of labour


Labour
Spare capacity
Full capacity
Relevant cost = $nil
Can hire more labour, i.e. take on extra staff or pay overtime
Can't hire more labour
Relevant cost = extra cost of labour
Relevant cost = opportunity cost of diverting labour, i.e. lost contribution **AND** extra labour cost

6 Relevant costs associated with non-current assets

Based on the comments above we can summarise the relevant costs associated with non-current assets as follows:


Non-current Asset
New Asset
Existing Asset
Relevant cash flows:
• Purchase price
• Scrap/disposal proceeds
Relevant cost is opportunity cost
Higher of
Sales proceeds
Lost contribution from use in other department

Items that are not relevant

- Depreciation is not a cash flow so is never relevant.
- Profit or loss on disposal incorporates accumulated depreciation so is not relevant – instead look at the cash element only – i.e. the scrap proceeds.
- The original purchase price of existing machinery is a sunk cost.
- The carrying value of existing machinery is a combination of the original price (sunk) and accumulated depreciation (not a cash flow).

7 One-off contracts

When a business is presented with a one-off contract, it should apply relevant costing principles to establish the cash flows associated with the project in order to help set a price.

The minimum contract price = the total net relevant cash flow associated with the contract.

Comments on the method used

- The minimum price is effectively a break-even price, so will give the firm no gain or loss.
- If the contract price does not cover these cash flows then it should be rejected as the company will have less cash if it accepts the contract.
- Any price higher than the minimum will mean that the company is better-off accepting the contract than rejecting it.

Further considerations:

- The price may be acceptable for a one-off contract but not for pricing all contracts and products – for example, when viewing a one-off contract fixed costs will probably be ignored as unavoidable. However, if every manager ignores fixed costs, then the company will end up making a loss.
- The minimum price obtained using relevant costing may be much lower than typical market prices. A firm may thus be reluctant to accept this price if it might affect the prices of other contracts in the future – for example, other customers may hear about the low prices offered and demand similar lower prices on their contracts.
- On the other hand a company may be willing to accept a loss on this contract if it increases the chances of winning subsequent contracts (albeit at what price?).

Test your understanding 3

Mr Smith has been asked to quote a price for a special contract. He has already prepared his tender but has asked you to review it for him.

He has pointed out to you that he wants to quote the minimum price as he believes this will lead to more lucrative work in the future.

The tender details are as follows:

Mr Smith's tender

		$
Material:	A 2,000 kgs @ $10 per kg	20,000
	B 1,000 kgs @ $15 per kg	15,000
	C 500 kgs @ $40 per kg	20,000
	D 50 litres @ $12 per litre	600
Labour:	Skilled 1,000 hrs @ $25 per hr	25,000
	Semi-skilled 2,000 hrs @ $15 per hr	30,000
	Unskilled, 500 hrs @ $10 per hr	5,000
Fixed overheads 3,500 hrs @ $12 per hr		42,000
Costs of preparing the tender:		
Mr Smith's time		1,000
other expenses		500
Minimum profit (5% of total costs)		7,955
		———
Minimum tender price		167,055
		———

Other information

Material A

- 1,000 kgs of this material is in stock at a cost of $5 per kg.
- Mr Smith has no alternative use for his material and intends selling it for $2 per kg.
- However, if he sold any he would have to pay a fixed sum of $300 to cover delivery costs.
- The current purchase price is $10 per kg.

Material B

- There is plenty of Material B in stock and it cost $18 per kg.
- The current purchase price is $15 per kg.
- The material is constantly used by Mr Smith in his business.

Material C

- The total amount in stock of 500 kgs was bought for $10,000 some time ago for another one-off contract that never happened.
- Mr Smith is considering selling it for $6,000 in total or using it as a substitute for another material, constantly used in normal production.
- If used in this latter manner it would save $8,000 of the other material.
- Current purchase price is $40 per kg.

Material D

- There are 100 litres of this material in stock.
- It is dangerous and if not used in this contract will have to be disposed of at a cost to Mr Smith of $50 per litre.
- The current purchase price is $12 per litre.

Skilled labour

- Mr Smith only hires skilled labour when he needs it.
- $25 per hour is the current hourly rate.

Semi-skilled labour

- Mr Smith has a workforce of 50 semi-skilled labourers who are currently not fully utilised.
- They are on annual contracts and the number of spare hours currently available for this project are 1,500. Any hours in excess of this will have to be paid for at time-and-a-half.
- The normal hourly rate is $15 per hour.

Unskilled labour

- These are currently fully employed by Mr Smith on jobs where they produce a contribution of $2 per unskilled labour hour.
- Their current rate is $10 per hour, although extra could be hired at $20 an hour if necessary.

Fixed overheads

- This is considered by Mr Smith to be an accurate estimate of the hourly rate based on his existing production.

Costs of preparing the tender

- Mr Smith has spent 10 hours working on this project at $100 per hour, which he believes is his charge-out rate.
- Other expenses include the cost of travel and research spent by Mr Smith on the project.

Profit

- This is Mr Smith's minimum profit margin which he believes is necessary to cover 'general day-to-day expenses of running a business'.

Required:

Calculate and explain for Mr Smith what you believe the minimum tender price should be.

Additional example on one-off contracts

A research contract, which to date has cost the company $150,000, is under review.

If the contract is allowed to proceed:

- it will be completed in approximately one year
- the results would then be sold to a government agency for $300,000.

Shown below are the additional expenses which the managing director estimates will be necessary to complete the work.

Materials

- This material for the contract has just been purchased at a cost of $60,000.
- It is toxic; if not used in this contract it must be disposed of at a cost of $5,000.

Labour

- Skilled labour is hard to recruit.
- The workers concerned were transferred to the contract from a production department, and at a recent meeting, the production manager claimed that if the men were returned to him they could generate sales of $150,000 in the next year.
  - The prime cost of these sales would be $100,000, including $40,000 for the labour cost itself.
  - The overhead absorbed into this production would amount to $20,000.

Research staff

- It has been decided that when work on this contract ceases, the research department will be closed.
- Research wages for the year are $60,000, and redundancy and severance pay has been estimated at $15,000 now, or $35,000 in one year's time.

Equipment

- The contract utilises a special microscope which cost $18,000 three years ago.
- It has a residual value of $3,000 in another two years, and a current disposal value of $8,000.
- If used in the contract it is estimated that the disposal value in a year's time will be $6,000.

Share of general building services

- The contract is charged with $35,000 pa to cover general building expenses.
- Immediately after the contract is discontinued, the space occupied could be sub-let for an annual rental of $7,000.

Required:

Advise the managing director as to whether the contract should be allowed to proceed, explaining the reasons for the treatment of each item. (Note: Ignore the time value of money.)

Solution		$
Relevant costs and revenues of proceeding with the contract		
(1)	Costs to date of $150,000 sunk – ignore.	–
(2)	Materials – in stock and will not be replaced There is an opportunity benefit of the disposal costs saved.	5,000
(3)	Labour cost – no spare capacity and additional labour can't be hired.	(90,000)
	Opportunity cost is lost contribution of $50,000 ($150k – $100k) plus the direct cost of labour of $40,000. The overhead will be incurred anyway and so should be ignored.	
(4)	Research staff costs:	(60,000)
	Wages for the year (cost would be saved if contract did not go ahead)	(20,000)
	Increase in redundancy pay due to the delay in closure of the department ($35,000 – $15,000)	

(5)	Equipment:	
	Deprival value if used in the project = disposal value	(8,000)
	Disposal proceeds in one year	6,000
	(All carrying values and depreciation figures are irrelevant)	
(6)	General building services are apportioned costs so they are irrelevant	–
	Opportunity costs of rental foregone	(7,000)
		–––––––
Total relevant cash flows associated with the contract		(174,000)
Sales value of contact		300,000
		–––––––
Increased contribution from contract		126,000
		–––––––

Advice. Proceed with the contract.

Test your understanding 4 – Relevant costs

(1) Z Co is pricing a new contract. The new contract requires the use of 50 tonnes of metal ZX. There are 25 tonnes of ZX in inventory at the moment, which were bought for $200 per tonne. Z Co no longer has any use for metal ZX. The current purchase price is $210 per tonne, and the metal could be disposed of for net scrap proceeds of $150 per tonne.

What cost should be charged to the new contract for metal ZX?

A $5,250
B $6,500
C $9,000
D $10,500

(2) 100 hours of unskilled labour, currently paid at $5.50 per hour, are needed for the contract. Z Co has no surplus capacity at the moment, but additional temporary staff could be hired at $6.50 per hour.

What is the relevant cost of the unskilled labour on the contract?

A $0
B $550
C $600
D $650

(3) 100 hours of skilled labour are needed for a contract. The company currently has 300 hours worth of spare capacity. There is a union agreement in place that there are no lay-offs. The workers are paid $8.50 per hour.

What is the relevant cost of the skilled labour on the contract?

A $0

B $650

C $850

D $2,550

(4) Equipment owned by Z Co has a carrying value of $1,800 and has been idle for some months. It could now be used on the new contract. If not used on this contract, the equipment could be sold for a net amount of $2,000. After use on the contract, the equipment would have no resale value, and would be dismantled.

What is the total relevant cost of the equipment to the contract?

A $0

B $200

C $1,800

D $2,000

(5) **Which of the following statements about relevant costing are true?**

(1) The opportunity cost is represented by the forgone potential benefit from the best rejected course of action.

(2) Materials can never have an opportunity cost, whereas labour can.

(3) The annual depreciation charge is not a relevant cost.

(4) Fixed costs would have a relevant cost element if a decision causes a change in their total expenditure.

(5) Notional costs are always relevant, as they make the estimate more realistic.

A Statements (1) and (2)

B Statements (1), (3) and (4)

C Statements (2), (3) and (5)

D Statements (4) and (5)

8 Make or buy decisions

Businesses may be faced with the decision whether to make components for their own products themselves, or to concentrate their resources on assembling the products, obtaining the components from outside suppliers instead of making them 'in house'.

If the resources are bought in, their purchase cost is wholly marginal (i.e. direct). However, if it is decided to manufacture the components internally, the comparative costs of doing so will be the direct materials and wages costs, plus the variable factory overhead.

If the total variable costs of internally manufactured components is seen to be greater than the cost of obtaining similar components elsewhere, it is obviously uneconomic to produce these items internally.

There are two types of make vs. buy decisions:

- Make or buy decisions with no limiting factors
- Make or buy decisions with limiting factors.

9 Make or buy decisions with no limiting factors

In a make or buy decision with no limiting factors, the relevant costs are the differential costs between the two options.

Test your understanding 5 – Make vs buy

KRS Co is considering whether to administer its own purchase ledger or to use an external accounting service. It has obtained the following cost estimates for each option:

Internal service department

	Cost	**Volume**
Purchase hardware/software	$320 pa	n/a
Hardware/software maintenance	$750 pa	n/a
Accounting stationery	$500 pa	n/a
Part-time account clerk	$6,000 pa	n/a

External services

Processing of invoices/credit notes	$0.50 per document	5,000 pa
Processing of cheque payments	$0.50 per cheque	4,000 pa
Reconciling supplier accounts	$2.00 per supplier per month	150 suppliers

Determine the cost effectiveness of outsourcing the accounting activities and identify the qualitative factors involved.

10 Make or buy with a limiting factor

In the presence of a limiting factor, the following step-by-step approach could be adopted with a make vs. buy question:

(1) The saving per unit of each product is calculated. Saving = Purchases price – variable costs to make.

(2) Divide this by the amount of scarce resource (a.k.a. limiting factor) each product uses. This gives the saving per unit of the limiting factor (LF).

(3) Rank products. The higher the saving per unit of LF, the greater the priority to make that should be given to the product.

(4) Once the priorities have been decided, the scarce resource is allocated to the products in the order of the priorities, until it is fully used up.

(5) Any products with unsatisfied demand can be satisfied by buying from the external source.

Test your understanding 6 – Make Or Buy with a limiting factor

A company manufactures four components (L, M, N and P) which are incorporated into different products. All the components are manufactured using the same general purpose machinery. The following production cost and machine hour data are available, together with the purchase prices from an outside supplier.

	L	M	N	P
Production cost:	$	$	$	$
Direct material	12	18	15	8
Direct labour	25	15	10	8
Variable overhead	8	7	5	4
Fixed overhead	10	6	4	3
Total	**55**	**46**	**34**	**23**
Purchase price from outside supplier ($)	57	55	54	50
Machine hours per unit (hours)	3	5	4	6

Manufacturing requirements show a need for 1,500 units of each component per week. The maximum number of general purpose machinery hours available per week is 24,000.

What number of units should be purchased from the outside supplier?

11 Make vs. buy: other issues to consider

In addition to the relative cost of buying externally compared to making in-house, management must consider a number of other issues before a final decision is made.

- **Reliability of external supplier:** can the outside company be relied upon to meet the requirements in terms of:
  - quantity required
  - quality required
  - delivering on time
  - price stability.
- **Specialist skills:** the external supplier may possess some specialist skills that are not available in-house.
- **Alternative use of resource:** outsourcing will free up resources which may be used in another part of the business.
- **Social:** will outsourcing result in a reduction of the workforce? Redundancy costs should be considered.
- **Legal:** will outsourcing affect contractual obligations with suppliers or employees?
- **Confidentiality:** is there a risk of loss of confidentiality, especially if the external supplier performs similar work for rival companies.
- **Customer reaction:** do customers attach importance to the products being made in-house?

12 Outsourcing pros and cons

Advantages	**Disadvantages**
Greater flexibility	Possibility of choosing wrong supplier
Lower investment risk	Loss of visibility and control over process
Improved cash flow	Possibility of increased lead times
Concentrates on core competence	
Enables more advanced technologies to be used without making investment	

13 Shut-down decisions

Part of a business, for example a department or a product, may appear to be unprofitable. The business may have to make a decision as to whether or not this area should be shut down.

The quantifiable cost or benefit of closure

The relevant cash flows associated with closure should be considered. For example:

- the lost contribution from the area that is being closed (= relevant cost of closure)
- savings in specific fixed costs from closure (= relevant benefit of closure) known penalties and other costs resulting from the closure, e.g. redundancy, compensation to customers (= relevant cost of closure)
- any known reorganisation costs (= relevant cost of closure)
- any known additional contribution from the alternative use for resources released (= relevant benefit of closure).

If the relevant benefits are greater than the relevant costs of closure then closure may occur. However, before a final decision is made the business should also consider the non-quantifiable factors discussed below.

Non-quantifiable costs and benefits of closure

- Some of the costs and benefits discussed above may be non-quantifiable at the point of making the shut-down decision:
  - penalties and other costs resulting from the closure (e.g. redundancy, compensation to customers) may not be known with certainty
  - reorganisation costs may not be known with certainty
  - additional contribution from the alternative use for resources released may not be known with certainty.
- Knock-on impact of the shut-down decision. For example, supermarkets often stock some goods which they sell at a loss. This is to get customers through the door, who they then hope will purchase other products which have higher profit margins for them. If the decision is taken to stop selling these products, then the customers may no longer come to the store.

Test your understanding 7

The management of Fiona Co is considering the closure of one of its operations, department 3, and the financial accountant has submitted the following report.

Department	**1**	**2**	**3**	**Total**
Sales (units)	5,000	6,000	2,000	13,000
Sales ($)	150,000	240,000	24,000	414,000
Cost of sales ($)				
Direct material	75,000	150,000	10,000	235,000
Direct labour	25,000	30,000	8,000	63,000
Production overhead	5,769	6,923	2,308	15,000
Gross profit ($)	44,231	53,077	3,692	101,000
Expenses ($)	15,384	18,461	6,155	40,000
Net profit ($)	28,847	34,616	(2,463)	61,000

Additional information:

- production overheads of $15,000 have been apportioned to the three departments on the basis of unit sales volume
- expenses are head office overheads, again apportioned to departments on sales volume.

As management accountant, you further ascertain that, on a cost driver basis:

- 50% of the production overheads can be directly traced to departments and so could be allocated on the basis 2:2:1.
- Similarly 60% of the expenses can be allocated 3:3:2, with the remainder not being possible to allocate.
- 80% of the so-called direct labour is fixed and cannot be readily allocated. The remaining 20% is variable and can be better allocated on the basis of sales volume.

(a) Restate the financial position in terms of the contribution made by each department and, based on these figures, make a clear recommendation.

(b) Discuss any other factors that should be considered before a final decision is made.

e.g

Additional example on shut-down decisions

Harolds fashion store comprises three departments – Men's Wear, Ladies' Wear and Unisex. The store budget is as follows:

	Men's	Ladies'	Unisex	Total
	$	$	$	$
Sales	40,000	60,000	20,000	120,000
Direct cost of sales	20,000	36,000	15,000	71,000
Department costs	5,000	10,000	3,000	18,000
Apportioned store costs	5,000	5,000	5,000	15,000
Profit/(loss)	10,000	9,000	(3,000)	16,000

It is suggested that Unisex be closed to increase the size of Men's and Ladies' Wear.

Required:

Determine what information is relevant or required.

Solution

Possible answers are as follows:

(a) Unisex earns $2,000 net contribution (apportioned costs will still be incurred and thus reapportioned to other departments).

(b) Possible increase in Men's/Ladies' sales volume.

(c) Will Unisex staff be dismissed or transferred to Men's/Ladies'?

(d) Reorganisation costs, e.g. repartitioning, stock disposal.

(e) Loss of custom because Unisex attracts certain types of customer who will not buy in Men's/Ladies'.

14 Further processing decisions

A further processing decision will be tested in the context of joint products in the exam.

Joint product costing was introduced in 'Management Accounting' (MA):

- Joint products arise where the manufacture of one product inevitably results in the manufacture of other products.
- The specific point at which individual products become identifiable is known as the split-off point.

- Costs incurred before the split-off point are called joint costs and must be shared between joint products produced.
- After separation products may be sold immediately or may be processed further. Any further processing costs are allocated directly to the product on which they are incurred.

The basis of apportionment of joint costs to products is usually one of the following:

(i) Sales value of production (also known as 'market value')

(ii) Production units

(iii) Net realisable value.

Illustration 1 – Valuation of joint products

Products A and B are two joint products with information as follows:

	Kgs produced	Kgs sold	Selling price per kg	Joint cost
Product A	100	80	$5	$750
Product B	200	150	$2	

(a) **Apportionment by production units**

$$\frac{\text{Joint cost}}{\text{Kgs produced}} = \frac{\$750}{300} = \$2.50 \text{ per kg for A and B}$$

Trading results are as follows:

	Product A		**Product B**		**Total**
Sales	80 × $5.00	$400	150 × $2.00	$300	$700
Cost of sales	80 × $2.50	($200)	150 × $2.50	($375)	($575)
Profit		$200		($75)	$125
Value of closing stock 20 × $2.50		$50	50 × $2.50	$125	

The production ratio is 100 : 200. This means that in order to obtain 1 kg of A, it is necessary to produce 2 kgs of B. For exam purposes, you should assume that the ratio of output is fixed.

(b) **Apportionment by market value at point of separation**

	Sales value of production	Proportion	Joint cost apportionment	Per kg
A : 100 × $5	$500	5/9	$417	$4.17
B : 200 × $2	$400	4/9	$333	$1.67
			750	

Trading results:

	A	**B**	**Total**
Sales	400	300	700
Cost of sales	333.6	250.5	585.1
Profit	66.4	49.5	114.9
Profit/Sales ratio	16.6%	16.5%	
Closing inventory	(20 × 4.17) = $83	(50 × $1.67) = $83	

Note that the apportionment is on the basis of proportionate sales value of production; Profit per unit will be the same (with a small rounding difference).

(c) **Apportionment by Net Realisable Value**

This approach should be used in situations where the sales value at the split-off point is not known – either because the product is not saleable, or if the examiner does not tell us.

Further information is needed:

	Further processing costs	Selling price after further processing
Product A	$280 + $ 2.00 per kg	$8.40
Product B	$160 + $1.40 per kg	$4.50

Apportionment of joint costs:

	Product A	Product B
Final sales value of production (100 × $8.40; 200 × $4.50)	$840	$900
Further processing cost (280 + 100 × $2; 160 + 200 × $1.40)	$480	$440
Net realisable value	$360	$460
Joint cost apportionment (360;460)	329	421
Joint cost per kg	$3.29	$2.10

Trading results (for common process only)

Sales			$700
Joint costs		$750	
Less closing inventory			
Net realisable value			
A : 20 × $3.29	$66		
B : 50 × $2.10	$105		
		(171)	
Cost of sales			($579)
Profit			$121

Test your understanding 8

The following is relevant for a production process for Period 1:

Direct material cost	$10,000
Direct labour cost	$5,000
Overheads	$3,000
Total costs	$18,000

The process produces joint products A and B, which are then sold at the prices given below. The output figure represents all of the output from the process:

	Product A	Product B
Units of output	2,000	8,000
Price per unit	$5	$2.50

Required:

Calculate the cost of sales, and gross profit for products A and B assuming:

(i) joint costs are apportioned by market value

(ii) joint costs are apportioned by production units.

Test your understanding 9

Dee Co produces three liquid pharmaceuticals L1, L2 and L3 from a common process. They must be produced and sold together.

1,000 litres of each of the three products are produced, incurring common process costs of $20,000 in total. The selling prices per litre for the three products at the end of the common process are:

	Selling price per litre
L1	$6
L2	$5
L3	$8

Alternatively, all three liquids can be processed further into products L1A, L2A and L3A. They also must all be sold together or not at all. The selling prices would then be:

	Selling price per litre
L1A	$9
L2A	$7
L3A	$10

If L1, L2 and L3 are processed further, the following

	Further processing costs
L1 to L1A	$1,000
L2 to L2A	$2,000
L3 to L3A	$2,400

Required:

Produce calculations to assess the viability of the common process, assuming that

(i) there is no external market for products L1A, L2A and L3A

(ii) there is an external market for products L1A, L2A and L3A.

Further processing decision

When deciding whether to process a particular product further or to sell after split-off only future incremental cash flows should be considered:

- Any difference in revenue and any extra costs.
- Joint costs are sunk at this stage and thus not relevant to the decision. (Note: if we are considering the viability of the whole process, then the joint costs would be relevant).

Test your understanding 10

A firm makes three joint products, X, Y and Z, at a joint cost of $400,000. Joint costs are apportioned on the basis of weight. Products X and Z are currently processed further.

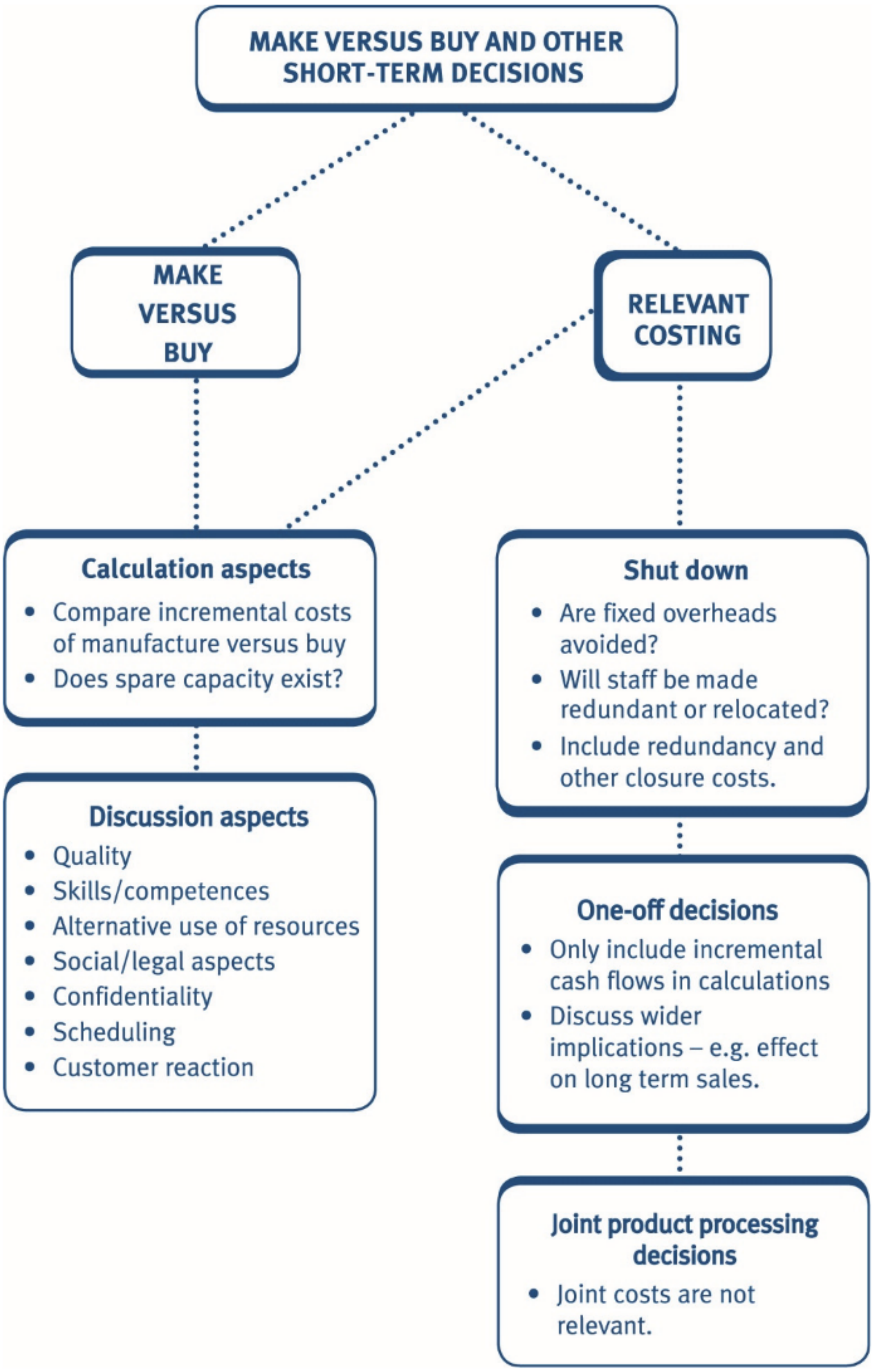
Product	Weight at split-off	Further processing costs (variable)	Sales
	(tonnes)	$000	$000
X	600	800	980
Y	200	–	120
Z	200	400	600

An opportunity has arisen to sell all three products at the split-off point for the following prices.

X	$200,000
Y	$120,000
Z	$160,000

Which of the products, if any, should the firm process further?

15 Chapter summary



Calculation aspects

- Compare incremental costs of manufacture versus buy
- Does spare capacity exist?

Discussion aspects

- Quality
- Skills/competences
- Alternative use of resources
- Social/legal aspects
- Confidentiality
- Scheduling
- Customer reaction

Shut down

- Are fixed overheads avoided?
- Will staff be made redundant or relocated?
- Include redundancy and other closure costs.

One-off decisions

- Only include incremental cash flows in calculations
- Discuss wider implications – e.g. effect on long term sales.

Joint product processing decisions

- Joint costs are not relevant.

Test your understanding answers

Test your understanding 1 – Relevant costs

(a) The salary is a relevant cost of $12,000. Do not be fooled by the mention of the fact that it is a fixed cost, it is a cost that is relevant to the decision to proceed with the future development of the new product. This is an example of a directly attributable fixed cost. A directly attributable fixed cost may also be called a product-specific fixed cost.

(b) The $2,500 additional running costs are relevant to the decision to purchase the new machine. The $3,000 per month saving in labour cost is relevant as it results from the decision to buy a new machine. The saving in overhead absorption is not relevant since we are not told that the total overhead expenditure will be altered.

(c) This is not a relevant cost for next month since it will be incurred even if the contract is cancelled today. If a decision is being made to close the office, this cost cannot be included as a saving to be made next month. However, it will be saved in the months after that so it will become a relevant cost saving from month 2 onwards.

(d) This is not a relevant cost of the decision to continue with the contract. The $75 is sunk and cannot be recovered even if the company does not proceed with the negotiations.

Test your understanding 2 – Opportunity cost

100% capacity = 102,000 ÷ 0.85 = 120,000 units

Spare capacity amounts to 18,000 units. So there is sufficient slack to meet the new order.

Variable costs = $330,000 less $75,000 = $255,000
Variable cost per unit = $255,000 ÷ 102,000 = $2.50
Contribution per unit from existing product = $3.25 – $2.50 = $0.75
Contribution per unit from new product = $2.80 – $2.50 = $0.30

	$
Increase in contribution from new product:	
$0.30 × 12,000 units	3,600
Fall in contribution from existing product:	
$0.75 × (12,000 ÷ 15) × 2	
$0.75 × 1,600	(1,200)
Net Gain in contribution	**2,400**

As fixed costs remain fixed even with an increased production, the net increase in profit amounts to $2,400.

Test your understanding 3

		$	$
Material A	1,000 kgs @ $2 – $300	1,700	
(note 1)	1,000 kgs @ $10	10,000	
			11,700
Material B (note 2)	1,000 kgs @$15		15,000
Material C (note 3)	500 kgs – opportunity cost		8,000
Material D (note 4)	50 litres @ $50		(2,500)
Skilled labour (note 5)	1,000 hrs @ $25		25,000
Semi-skilled labour (note 6)	500 hrs @ $22.50		11,250
Unskilled labour (note 7)	500 hrs @ $12 (opportunity cost)		6,000
Minimum tender price = total of relevant cash flows			74,450

Notes

(1) There are 1,000 kgs in stock and these will not be replaced. These would otherwise be sold at a net gain of $1,700. This gain is therefore foregone as a result of using this material in the contract. The other 1,000 kgs are out of stock and therefore the relevant cost is the current purchase price of $10 per kg.

(2) The material is in stock but will be replaced and therefore the relevant cost is the current purchase price of $15 per kg.

(3) The material is in stock and there are two options if this material is not used for the contract:

Option 1 – Sell it for $6,000.

Option 2 – Use it as a substitute and save $8,000.

Option 2 is preferable. This is therefore the opportunity cost of using it in the contract.

(4) The material is in stock and will not be replaced. The cost of disposing of 50 litres will be saved (@ $50/litre, i.e. $2,500). Saving this cost is a relevant benefit.

(5) The incremental cost of paying for the labour needed.

(6) 1,500 spare hours have already been paid for as the workforce are on annual contracts. The additional cash flow is therefore the extra 500 hours that are needed at time-and-a-half.

(7) For each hour diverted from their normal jobs contribution of $2 will be foregone. This together with the cost of paying the workers to do the project amounts to a relevant cost of $12 per kg. They would not be hired at $20 per hour as this is more expensive.

(8) Fixed overheads can be ignored as they are not incremental.

(9) Costs of preparing the tender are all sunk costs and hence must be ignored.

(10) Profit element should be ignored since a minimum contract price is being calculated.

Test your understanding 4 – Relevant costs

(1) **C**

The only alternative use for the material held in inventory is to sell it for scrap. To use 25 tonnes on the contract is to give up the opportunity of selling it for 25 × $150 = $3,750. Z Co must then purchase a further 25 tonnes, and assuming this is in the near future, it will cost $210 per tonne. Therefore, the contract must be charged with

25 tonnes × $150	$3,750
25 tonnes × $210	$5,250
	$9,000

(2) **D**

Spare capacity does not exist, but extra employees may be hired, therefore the relevant cost is the cost of hiring temporary staff at $6.50 per hour, i.e. 100 hours × $6.50 = $650.

(3) **A**

The relevant cost of the semi-skilled labour on the contract is NIL. Spare capacity exists, and therefore the relevant cost of the semi-skilled labour is $0.

(4) **D**

The asset will not be replaced, but it could now be sold for $2,000. If not sold now, it would have no other value. Therefore the relevant cost is the opportunity cost now, i.e. $2,000.

(5) **B**

Statement 2 is not correct: materials can have an alternative use that can exceed their value in the project being considered.

Statement 5 is not correct either: notional costs are used to make cost estimates more realistic; however, they are not real cash flows and are not considered to be relevant.

Test your understanding 5 – Make vs buy

Annual internal processing costs

Hardware and software	$320	
Hardware/software annual maintenance	$750	
Accounting stationery	$500	
Part time accounts clerk	$6,000	
Total	$7,570	
Annual outsourcing costs		
Processing of invoices/credit notes	$2,500	5,000 × $0.50
Processing of cheque payments	$2,000	4,000 × $0.50
Reconciling supplier accounts	$3,600	150 × $2 × 12
Total	$8,100	

It would not be cost effective to outsource the accounting activities. The present costs of $7,570 would rise to $8,100 pa.

Qualitative factors include:

- predicted volumes – higher volumes will make outsourcing more expensive
- the quality of supply – will the external supplier make more errors?
- security of information.

Test your understanding 6 – Make Or Buy with a limiting factor

The following method could be adopted in this example:

(1) The saving per unit of each product is calculated. Saving = Purchases price – VC to make.

(2) Divide this by the amount of scarce resource (a.k.a. limiting factor) each product uses. This gives the saving per unit of limiting factor (LF).

(3) Rank. The higher the saving per unit of LF the greater the priority to make that should be given to the product.

(4) Once the priorities have been decided, the scarce resource is allocated to the products in the order of the priorities until it is fully used up.

(5) Any products with unsatisfied demand can be satisfied by buying from the external source.

Steps:

(1) Calculate saving = Purchases price – VC to make:

	L	**M**	**N**	**P**
External purchase price	$57	$55	$54	$50
Variable costs to make	$45	$40	$30	$20
Saving	$12	$15	$24	$30

(2) Calculate the saving per unit of limiting factor/scarce resource:

	L	**M**	**N**	**P**
Saving	$12	$15	$24	$30
Scarce resource (machine hours) per unit	3 hours	5 hours	4 hours	6 hours
Saving per unit of the scarce resource	$4	$3	$6	$5

(3) Rank

	L	**M**	**N**	**P**
Saving per unit of the scarce resource	$4	$3	$6	$5
Rank: product to make in priority	3	4	1	2

(4) Allocate scarce resource of 24,000 machine hours to production

Make all Ns (1,500 units). This will use up 1,500 × 4 hours = 6,000 hours.

Then, make all Ps (1,500 units). This will use up 1,500 × 6 hours = 9,000 hours. The cumulative total is 6,000 + 9,000 = 15,000 hours.

Then, make all Ls (1,500 units). This will use up 1,500 × 3 hours = 4,500 hours. The cumulative total is 15,000 + 4,500 = 19,500 hours.

This leaves (24,000 – 19,500) = 4,500 hours, in which to make

$$\frac{4{,}500}{5} = \text{ 900 units of Product M}$$

(5) Unsatisfied demand = 1,500 Ms – 900 Ms = 600 Ms. These will have to be bought externally.

	L	M	N	P
Variable production cost	$45	$40	$30	$20
External cost	$57	$55	$54	$50
Incremental cost	**$12**	**$15**	**$24**	**$30**
Hours per unit	÷ 3	÷ 5	÷ 4	÷ 6
Incremental cost per hour	**$4**	**$3**	**$6**	**$5**
Cheapest per hour	2nd	1st	4th	3rd

The analysis shows that it is actually cheaper to try and make ALL the components within the factory.

Hours required to make 1,500 units of each component:

(1,500 × 3) + (1,500 × 5) + (1,500 × 4) + (1,500 × 6) = 27,000 hours

The company only has 24,000 hours available. So, 3,000 hours of work must be sub-contracted. The CHEAPEST component per hour must be bought externally. This is component M.

3,000 hours of time on M equates to 3,000 ÷ 5 = **600 units of M**.

Test your understanding 7

(a) First of all we must restate the figures so that they present the situation in its true light. Only relevant cash flows should be considered. This will enable each department to be readily evaluated on its locally controllable performance.

Department	**1**	**2**	**3**	**Total**
Sales volume (units)	5,000	6,000	2,000	13,000
Sales value ($)	150,000	240,000	24,000	414,000
Cost of sales: ($)				
Direct material	75,000	150,000	10,000	235,000
Direct labour (note 1)	4,846	5,815	1,939	12,600
Prodn overhead (note 2)	3,000	3,000	1,500	7,500
Expenses (note 3)	9,000	9,000	6,000	24,000
Contribution ($)	58,154	72,185	4,561	134,900
Other costs ($):				
Labour (note 4)				(50,400)
Overhead (note 5)				(7,500)
Expenses (note 6)				(16,000)
Net profit				61,000

Notes:

(1) 80% of the labour cost is fixed and is therefore excluded from the contribution calculation. The remaining 20% has been allocated on the basis of sales volume.

(2) Only 50% of the production overheads can be directly allocated to the departments. This has been allocated in the ratio 2:2:1.

(3) Only 60% of the expenses can be directly traced to the departments. This has been allocated in the ratio 3:3:2.

(4) Fixed cost of labour is 80%.

(5) This is the remaining 50% of overheads that can't be allocated to departments.

(6) This is the remaining 40% of expenses that can't be allocated to departments.

Conclusion

From the restated figures department 3 should be kept open since:

- The department is making a contribution of $4,561 to the overall profit of the business.
- The apparent loss arises purely from inappropriate apportionment of overheads and expenses.
- If the department were closed:
  - there would be a loss of $4,561 contribution to the business and
  - on the assumption there would be no further saving on fixed costs, the profit would be reduced to $56,439.

(b) Consideration must be given to the following factors which may be non-quantifiable at present:

- Redundancy costs or costs relating to the disposal of equipment if department 3 is closed.
- The possible loss of business due to products from department 3 being unavailable to customers who buy from other departments at the same time.
- The reorganisation costs that may arise from the closure of department 3.
- Additional benefits of closure of department 3 such as labour and machinery being used to generate contribution elsewhere in the business.

Test your understanding 8

(a) **Market value basis**

	Product A	**Product B**	**Total**
Sales value	$10,000	$20,000	$30,000
Joint costs apportioned (W1)	$6,000	$12,000	$18,000
Gross profit	$4,000	$8,000	$12,000

Working:

Joint costs allocated to Product A = $\frac{10,000}{30,000}$ \$18,000 = \$6,000

Joint costs allocated to Product B = $\frac{20,000}{30,000}$ \$18,000 = \$12,000

(b) **Production units basis**

	Product A	**Product B**	**Total**
Sales value	$10,000	$20,000	$30,000
Joint costs apportioned (W1)	$3,600	$14,400	$18,000
Gross profit	$6,400	$5,600	$12,000

Working:

Total output units = 2,000 + 8,000 = 10,000

Joint costs allocated to Product A = $\frac{2,000}{10,000}$ \$18,000 = \$3,600

Joint costs allocated to Product B = $\frac{8,000}{10,000}$ \$18,000 = \$14,400

Test your understanding 9

(i) **If there is no external market for products L1A, L2A and L3A, we can only sell post separation, without further processing.**

Assuming that all output can be sold at the prices given:

	Quantity	**Selling price per litre**	**Sales Revenue**
L1	1,000 litres	$6	$6,000
L2	1,000 litres	$5	$5,000
L3	1,000 litres	$8	$8,000
		Total revenue	**$19,000**

Total cost of common process = $20,000.

Loss = $1,000 and therefore the common process is not financially viable.

(ii) **If there is an external market for products L1A, L2A and L3A:**

	Quantity	**Selling price per litre**	**Sales Revenue**
L1A	1,000 litres	$9	$9,000
L2A	1,000 litres	$7	$7,000
L3A	1,000 litres	$10	$10,000
		Total revenue	**$26,000**
		Common costs	$(20,000)
		Further costs	$(5,400)
		Net revenue after further processing	**$600**

Based on this analysis, further processing and selling is financially viable.

Test your understanding 10

The pre-separation (i.e. "joint") costs are not incremental and so can be ignored. The only incremental cash flows are as follows:

Product	**X**	**Y**	**Z**
	$000	$000	$000
Additional revenue from further processing	780	n/a	440
Additional costs from further processing	800	n/a	400
Benefit/(cost) of further processing	(20)		40

Thus only Z should be processed further.

Chapter

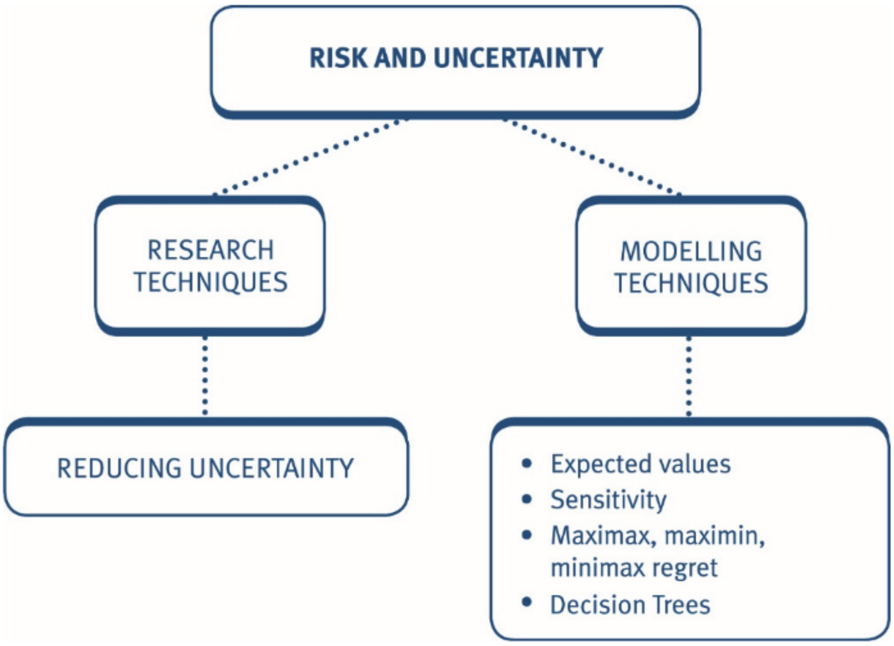
9

Risk and uncertainty

Chapter learning objectives

Upon completion of this chapter you will be able to:

- Suggest research techniques to reduce uncertainty e.g. focus groups, market research.
- Explain the use of simulation, expected values and sensitivity.
- Apply expected values and sensitivity to decision-making problems.
- Apply the techniques of maximax, maximin, and minimax regret to decision-making problems including the production of profit tables.
- Interpret a decision tree and use it to solve a multi-stage decision problem.
- Calculate the value of perfect and imperfect information.



1 Introduction

All businesses face risk. **Risk** is the variability of possible returns.

Risk management is important in a business. It is the process of understanding and managing the risks that an organisation is inevitably subject to.

Distinction between risk and uncertainty

Risk: there are a number of possible outcomes and the probability of each outcome is known.

For example, based on past experience of digging for oil in a particular area, an oil company may estimate that they have a 60% chance of finding oil, and a 40% chance of not finding oil.

Uncertainty: there are a number of possible outcomes but the probability of each outcome is not known.

For example, the same oil company may dig for oil in a previously unexplored area. The company knows that it is possible for them to either find or not find oil but it does not know the probabilities of each of these outcomes.

The role of market research techniques

Market research is an important means of assessing and reducing uncertainty. For example, about the likely responses of customers to new products, new advertising campaigns and price changes.

A number of research techniques are available:

- Focus Groups
- Desk research (secondary research).
- Field research (primary research). This includes:
  - motivational and
  - measurement research.

Each method will be reviewed in turn.

Focus groups

Focus groups are a common market research tool involving small groups (typically eight to ten people) selected from the broader population. The group is interviewed through facilitator-led discussions in an informal environment in order to gather their opinions and reactions to a particular subject.

For example, a supermarket may use a focus group before a product launch decision is made, in order to gather opinions on a new range of pizzas.

Problems with focus groups

- Results are qualitative.
- The small sample size means that results may not be representative.
- Individuals may feel under pressure to agree with other members or to give a 'right' answer.
- Their cost and logistical complexity is frequently cited as a barrier, especially for smaller companies. On-line focus groups are becoming more popular and help to address this issue.

Desk research

- The information is collected from secondary sources.
- It obtains existing data by studying published and other available sources of information. For example, press articles, published accounts, census information.
- It can often eliminate the need for extensive field work.

Factors to consider when using desk research

- It may not be exactly what the researcher wants and may not be totally up to date or accurate.
- However, it is quicker and cheaper than field research.

There are three main types of information that can be collected by desk research:

- Economic intelligence can be defined as information relating to the economic environment within which a company operates. It is concerned with such factors as gross national product (GNP), investment, expenditure, population, employment, productivity and trade. It provides an organisation with a picture of past and future trends in the environment and with an indication of the company's position in the economy as a whole. A great deal of information is freely available in this area from sources such as government ministries, the nationalised industries, universities and organisations such as the OECD.
- Market intelligence is information about a company's present or possible future markets. Such information will be both commercial and technical, for example, the level of sales of competitors' products recorded by the Business Monitor or Census of Production; the product range offered by existing or potential competitors; the number of outlets forming the distribution network for a company's products; the structure of that network by size, location and relation to the end user; and the best overseas markets for a company.
- Internal company data is perhaps the most neglected source of marketing information. Companies tend to record their sales information for accountancy purposes or for the management of the sales force. Conversely, many companies, especially blue-chips and public services, can often be seen to produce reams of data for no apparent reason, or because 'we always have done'. Rarely is the information collected in a form in which it can readily be used by marketing management.

Field research

- Information is collected from primary sources by direct contact with a targeted group.
- Although it is more expensive and time consuming than desk research the results should be more accurate, relevant and up to date.
- There are two types of field research:
  - motivational research
  - measurement research.

Motivational research – the objective is to understand factors that influence why consumers do or do not buy particular products.

Motivational research techniques

Some of the more common techniques in motivational research are:

- Depth interviewing – undertaken at length by a trained person who is able to appreciate conscious and unconscious associations and motivations and their significance.
- Group interviewing – where between six and ten people are asked to consider the relevant subject (object) under trained supervision.
- Word association testing – on being given a word by the interviewer, the first word that comes into the mind of the person being tested is noted.
- Triad testing – where people are asked which out of a given three items they prefer. If the three are brands of a given type of product (or three similar types), replies may show a great deal about which features of a product most influence the buying decision.

Measurement research – the objective here is to build on the motivation research by trying to quantify the issues involved.

- Sample surveys are used to find out how many people buy the product, what quantity each type of buyer purchases, and where and when the product is bought.
- This sort of information can also be collected in retail environments at the point of sale, for example, through the use of loyalty cards.

Types of measurement research

It is also possible (less accurately) to assess roughly the importance of some reasons for buying or not buying a product. The main types of measurement are:

Random sampling – where each person in the target population has an equal chance of being selected. Such samples are more likely to be representative, making predictions more reliable. However, the technique may be unfeasible in practice.

Quota sampling – where samples are designed to be representative with respect to pre-selected criteria.

- For example, if the target population is 55% women and 45% men, then a sample of 200 people could be structured so 110 women and 90 men are asked, rather than simply asking 200 people and leaving it up to chance whether or not the gender mix is typical.
- The main disadvantage of quota sampling is that samples may still be biased for non-selected criteria.

Panelling – where the sample is kept for subsequent investigations, so trends are easier to spot.

Surveying by post – the mail shot method. Unfortunately the sample becomes self-selecting and so may be biased.

Observation – e.g. through the use of cameras within supermarkets to examine how long customers spend on reading the nutritional information on food packaging.

2 Other methods of dealing with risk and uncertainty

In addition to the research techniques discussed, the following methods can be used to address risk or uncertainty.

- Sensitivity analysis
- Simulation
- Expected values
- Maximax, maximin and minimax regret
- Decision Trees.

Each method will be reviewed in turn.

3 Sensitivity analysis

Sensitivity analysis takes each uncertain factor in turn, and calculates the change that would be necessary in that factor before the original decision is reversed. Typically, it involves posing 'what-if' questions.

By using this technique it is possible to establish which estimates (variables) are more critical than others in affecting a decision.

The process is as follows:

- Best estimates for variables are made and a decision arrived at.
- Each of the variables is analysed in turn to see how much the original estimate can change before the original decision is reversed. For example, it may be that the estimated selling price can fall by 5% before the original decision to accept a project is reversed.
- Estimates for each variable can then be reconsidered to assess the likelihood of the estimate being wrong. For example, what is the chance of the selling price falling by more than 5%?
- The maximum possible change is often expressed as a percentage.

Illustration 1 – Sensitivity analysis

A manager is considering a make v buy decision based on the following estimates:

	If made in-house	If buy in and re-badge
	$	$
Variable production costs	10	2
External purchase costs	–	6
Ultimate selling price	15	14

You are required to assess the sensitivity of the decision to the external purchase price.

Solution

Step 1: What is the original decision?

Comparing contribution figures, the product should be bought in and rebadged:

	If made in-house	If buy in and re-badge
	$	$
Contribution	5	6

Step 2: Calculate the sensitivity (to the external purchase price)

For indifference, the contribution from outsourcing needs to fall to $5 per unit. Thus the external purchase price only needs to increase by $1 per unit (or $1/$6 = 17%). If the external purchase price rose by more than 17% the original decision would be reversed.

Strengths of sensitivity analysis

- There is no complicated theory to understand.
- Information will be presented to management in a form which facilitates subjective judgement to decide the likelihood of the various possible outcomes considered.
- It identifies areas which are crucial to the success of the project. If the project is chosen, those areas can be carefully monitored.

Weaknesses of sensitivity analysis

- It assumes that changes to variables can be made independently, e.g. material prices will change independently of other variables. Simulation allows us to change more than one variable at a time.
- It only identifies how far a variable needs to change; it does not look at the probability of such a change.
- It provides information on the basis of which decisions can be made but it does not point to the correct decision directly.

4 Simulation

Simulation is a modelling technique that shows the effect of more than one variable changing at the same time.

It is often used in capital investment appraisal.

The Monte Carlo simulation method uses random numbers and probability statistics. It can include all random events that might affect the success or failure of a proposed project – for example, changes in material prices, labour rates, market size, selling price, investment costs or inflation.

The model identifies key variables in a decision: costs and revenues, say. Random numbers are then assigned to each variable in a proportion in accordance with the underlying probability distribution. For example, if the most likely outcomes are thought to have a 50% probability, optimistic outcomes a 30% probability and pessimistic outcomes a 20% probability, random numbers, representing those attributes, can be assigned to costs and revenues in those proportions.

A powerful computer is then used to repeat the decision many times and give management a view of the likely range and level of outcomes. Depending on the management's attitude to risk, a more informed decision can be taken.

This helps to model what is essentially a one-off decision using many possible repetitions. It is only of any real value, however, if the underlying probability distribution can be estimated with some degree of confidence.

Illustration 2 – The MP Organisation

The MP Organisation is an independent film production company. It has a number of potential films that it is considering producing, one of which is the subject of a management meeting next week. The film which has been code named CA45 is a thriller based on a novel by a well-respected author.

The expected revenues from the film have been estimated as follows: there is a 30% chance it may generate total sales of $254,000; 50% chance sales may reach $318,000 and 20% chance they may reach $382,000.

Expected costs (advertising, promotion and marketing) have also been estimated as follows: there is a 20% chance they will reach approximately $248,000; 60% chance they may get to $260,000 and 20% chance of totalling $272,000.

In a Monte Carlo simulation, these revenues and costs could have random numbers assigned to them:

Sales revenue	**Probability**	**Assign random numbers (assume integers)**
$254,000	0.30	00–29
$318,000	0.50	30–79
$382,000	0.20	80–99
Costs		
$248,000	0.20	00–19
$260,000	0.60	20–79
$272,000	0.20	80–99

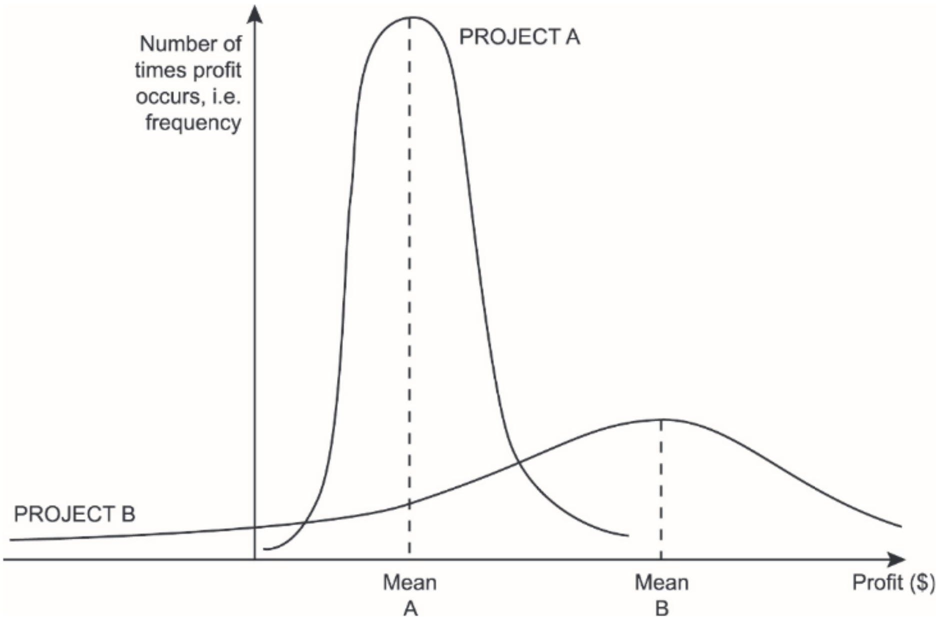
A computer could generate 20-digit random numbers such as 98125602386617556398. These would then be matched to the random numbers assigned to each probability and values assigned to 'Sales Revenues' and 'Costs' based on this. The random numbers generated give 5 possible outcomes in our example:

Random number	**Sales revenue in** $000	**Random number**	**Costs in** $000	**Profit**
98	382	12	248	134
56	318	02	248	70
38	318	66	260	58
17	254	55	260	(6)
63	318	98	272	48

Illustration 3 – Simulation

[**Note:** The illustration below is only here to show how a simulation works. You only need to be able to explain how one works, in the exam – not use one.]

A business is choosing between two projects, project A and project B. It uses simulation to generate a distribution of profits for each project.



Required:

Which project should the business invest in?

Solution

Project B has a higher average profit but is also more risky (more variability of possible profits).

However, if the business would prefer to minimise its exposure to risk, it would take on project A. This has a lower risk but also a lower average return.

Project A has a lower average profit but is also less risky (less variability of possible profits).

There is no correct answer. All simulation will do is give the business the above results. It will not tell the business which is the better project.

If the business is willing to take on risk, they may prefer project B since it has the higher average return.

There are major **drawbacks** of simulation:

- It is not a technique for making a decision, only for obtaining more information about the possible outcomes.
- Models can become extremely complex.
- The time and costs involved in their construction can be more than is gained from the improved decisions.
- Probability distributions may be difficult to formulate.

Simulation in a chain of betting shops

Simulation for a chain of betting shops would be particularly useful on an operational level for analysing the possible implications of a single event, such as a major horse race or football match:

- Possible outcomes are easy to identify (e.g. win, lose, draw, 2–1, 3–0, etc.)
- Quoted odds can help estimate probabilities
- The outcomes of the simulation could be used to assess impact on cash flow, whether bets should be laid off with other betting agents to reduces risk, etc.

Simulation could also be used for wider strategic analysis such as for assessing the possibility and implications of stricter anti-gambling legislation.

5 Expected values (EVs)

An expected value is a weighted average of all possible outcomes. It calculates the average return that will be made if a decision is repeated again and again. In other words, it is obtained by multiplying the value of each possible outcome (x), by the probability of that outcome (p), and summing the results.

The formula for the expected value is **EV = Σpx**

Illustration 4 – Calculating EVs

An organisation is considering launching a new product. It will do so if the expected value of the total revenue is in excess of $1,000. It is decided to set the selling price at $10. After some investigation a number of probabilities for different levels of sales revenue are predicted; these are shown in the following table:

Units sold	Revenue	Probability	Pay-off
	$		$
80	800	0.15	120
100	1,000	0.50	500
120	1,200	0.35	420
		———	———
		1.00	EV = 1,040

The expected sales revenue at a selling price of $10 per unit is $1,040, that is [800 × 0.15] + [1,000 × 0.50] + [1,200 × 0.35]. In preparing forecasts and making decisions management may proceed on the assumption that it can expect sales revenue of $1,040 if it sets a selling price of $10 per unit. The actual outcome of adopting this selling price may be sales revenue that is higher or lower than $1,040. And $1,040 is not even the most likely outcome; the most likely outcome is $1,000, since this has the highest probability.

Since the expected value shows the long run average outcome of a decision which is repeated time and time again, it is a useful decision rule for a **risk neutral decision maker**. This is because a risk neutral investor neither seeks risk or avoids it; they are happy to accept an average outcome.

Advantages and disadvantages of EVs

Advantages:

- Takes uncertainty into account by considering the probability of each possible outcome and using this information to calculate an expected value.
- The information is reduced to a single number resulting in easier decisions.
- Calculations are relatively simple.

Disadvantages:

- The probabilities used are usually very subjective.
- The EV is merely a weighted average and therefore has little meaning for a one-off project.
- The EV gives no indication of the dispersion of possible outcomes about the EV, i.e. the risk, so it gives a risk neutral decision.
- The EV may not correspond to any of the actual possible outcomes.

Pay-off tables

A profit table (pay-off table) can be a useful way to represent and analyse a scenario where there is a range of possible outcomes and a variety of possible responses. A pay-off table simply illustrates all possible profits/losses.

Illustration 5 – Geoffrey Ramsbottom

Geoffrey Ramsbottom runs a kitchen that provides food for various canteens throughout a large organisation. A particular salad is sold to the canteen for $10 and costs $8 to prepare. Therefore, the contribution per salad is $2.

Based upon past demands, it is expected that, during the 250-day working year, the canteens will require the following daily quantities:

On 25 days of the year	40 salads
On 50 days of the year	50 salads
On 100 days of the year	60 salads
On 75 days	70 salads
Total 250 days	

The kitchen must prepare the salad in batches of 10 meals. Its staff has asked you to help them decide how many salads it should supply for each day of the forthcoming year.

Solution

Constructing a pay-off table:

- With pay-off tables it is common to put the decision variable across the top of the payoff table (i.e. columns) and the risk variable down the side (rows).
- If 40 salads will be required on 25 days of a 250-day year, the probability that demand = 40 salads is:

P(Demand of 40) = 25 days ÷ 250 days

P(Demand of 40) = 0.1

- Likewise, P(Demand of 50) = 0.20; P(Demand of 60 = 0.4) and P (Demand of 70 = 0.30).
- Now let's look at the different values of profit or losses depending on how many salads are supplied and sold. For example, if we supply 40 salads and all are sold, our profits amount to 40 × $2 = 80.
- If however we supply 50 salads but only 40 are sold, our profits will amount to 40 × $2 – (10 unsold salads × $8 unit cost) = 0.

We can now continue this process to construct a pay-off table as follows:

			Daily supply			
		Probability	**40 salads**	**50 salads**	**60s salads**	**70 salads**
Daily demand	40 salads	0.10	$80	$0	($80)	($160)
	50 salads	0.20	$80	$100	$20	($60)
	60 salads	0.40	$80	$100	$120	$40
	70 salads	0.30	$80	$100	$120	$140

6 Maximax, maximin and minimax regret

When probabilities are not available, there are still tools available for incorporating uncertainty into decision making.

Maximax

The maximax rule involves selecting the alternative that maximises the maximum pay-off achievable.

This approach would be suitable for an optimist, or **'risk-seeking'** investor, who seeks to achieve the best results if the best happens.

Illustration 6 – The Maximax rule

Following up from the pay-off table example, Geoffrey Ramsbottom's table looks as follows:

			Daily supply			
		Probability	**40 salads**	**50 salads**	**60s salads**	**70 salads**
Daily demand	40 salads	0.10	$80	$0	($80)	($160)
	50 salads	0.20	$80	$100	$20	($60)
	60 salads	0.40	$80	$100	$120	$40
	70 salads	0.30	$80	$100	$120	$140

The manager who employs the maximax criterion is assuming that whatever action is taken, the best will happen; they are a risk-taker. How many salads will he decide to supply?

Solution

Here, the highest maximum possible pay-off is $140. We should therefore decide to supply 70 salads a day.

Test your understanding 1 – Applying maximax

A company is choosing which of three new products to make (A, B or C) and has calculated likely pay-offs under three possible scenarios (I, II or III), giving the following pay-off table.

Profit (loss)		**Product chosen**	
Scenario	**A**	**B**	**C**
I	20	80	10
II	40	70	100
III	50	(70)	40

Required:

Using maximax, which product would be chosen?

Maximin

The maximin rule involves selecting the alternative that maximises the minimum pay-off achievable.

The investor would look at the worst possible outcome at each supply level, then selects the highest one of these. The decision maker therefore chooses the outcome which is guaranteed to minimise their losses. In the process, they lose out on the opportunity of making big profits.

This approach would be appropriate for a **risk-averse** pessimist who seeks to achieve the best results if the worst happens.

Test your understanding 2 – Applying maximin

Required:

Using the information from the previous TYU apply the maximin rule to decide which product should be made.

Illustration 7 – The 'Maximin' rule

Following up from the pay-off table example, Geoffrey Ramsbottom's table looks as follows:

			Daily supply			
		Probability	**40 salads**	**50 salads**	**60s salads**	**70 salads**
	40 salads	0.10	$80	$0	($80)	($160)
Daily demand	50 salads	0.20	$80	$100	$20	($60)
	60 salads	0.40	$80	$100	$120	$40
	70 salads	0.30	$80	$100	$120	$140

How many salads should Geoffrey supply, using the Maximin rule?

Solution

If we decide to supply 40 salads, the minimum pay-off is $80.

If we decide to supply 50 salads, the minimum pay-off is $0.

If we decide to supply 60 salads, the minimum pay-off is ($80).

If we decide to supply 70 salads, the minimum pay-off is ($160).

The highest minimum payoff arises from supplying **40 salads**.

The Minimax Regret rule

The minimax regret strategy is the one that minimises the maximum regret. Essentially, this is the technique for a ‘sore loser’ who does not wish to make the wrong decision.

‘Regret’ in this context is defined as the opportunity loss through having made the wrong decision.

Illustration 8 – The 'Minimax Regret' rule

Following up from the pay-off table example, Geoffrey Ramsbottom's table looks as follows:

			Daily supply			
		Probability	**40 salads**	**50 salads**	**60s salads**	**70 salads**
Daily demand	40 salads	0.10	$80	$0	($80)	($160)
	50 salads	0.20	$80	$100	$20	($60)
	60 salads	0.40	$80	$100	$120	$40
	70 salads	0.30	$80	$100	$120	$140

How many salads should Geoffrey decide to supply if the minimax regret rule is applied?

Solution

If the minimax regret rule is applied to decide how many salads should be made each day, Geoffrey needs to calculate the 'regrets'. This means Geoffrey needs to find the biggest pay-off for each demand row, then subtract all other numbers in this row from the largest number.

For example, if the demand is 40 salads, Geoffrey will make a maximum profit of $80 if they all sell. If Geoffrey had decided to supply 50 salads, he would achieve a nil profit. The difference, or 'regret' between that nil profit and the maximum of $80 achievable for that row is $80.

Regrets can be tabulated as follows:

		Daily supply			
		40 salads	**50 salads**	**60s salads**	**70 salads**
Daily demand	40 salads	$0	$80	$160	$240
	50 salads	$20	$0	$80	$160
	60 salads	$40	$20	$0	$80
	70 salads	$60	$40	$20	$0
	Maximum regret	**$60**	**$80**	**$160**	**$240**

The lowest figure for maximum regret ($60) occurs when **40 salads** are supplied. This is therefore the optimal strategy for someone following the maximum regret strategy.

7 Decision trees

A decision tree is a diagrammatic representation of a multi-decision problem, where all possible courses of action are represented, and every possible outcome of each course of action is shown.

Decision trees should be used where a problem involves a series of decisions being made and several outcomes arise during the decision-making process. Decision trees force the decision maker to consider the logical sequence of events. A complex problem is broken down into smaller, easier to handle sections.

The financial outcomes and probabilities are shown separately, and the decision tree is ‘rolled back’ by calculating expected values and making decisions.

Note: You will not be required to prepare a decision tree diagram in the exam, but you may be asked to interpret one.

Three step method

Step 1: Draw the tree from left to right, showing appropriate decisions and events/outcomes. (**Note**: this step will be completed for you already in the exam).

Some common symbols can be used: a **square** is used to represent a decision point (i.e. where a choice between different courses of action must be taken. A **circle** is used to represent a chance point. The branches coming away from a circle with have probabilities attached to them. All probabilities should add up to '1'.

Label the tree and relevant cash inflows/outflows and probabilities associated with outcomes.

Step 2: Evaluate the tree from right to left carrying out these two actions:

(a) Calculate an EV at each chance point.

(b) Choose the best option at each decision point.

Step 3: Recommend a course of action to management.

e.g

Decision trees

A university is trying to decide whether or not to advertise a new post-graduate degree programme.

The number of students starting the programme is dependent on economic conditions:

- If conditions are poor it is expected that the programme will attract 40 students without advertising. There is a 60% chance that economic conditions will be poor.
- If economic conditions are good it is expected that the programme will attract only 20 students without advertising. There is a 40% chance that economic conditions will be good.

If the programme is advertised and economic conditions are poor, there is a 65% chance that the advertising will stimulate further demand and student numbers will increase to 50. If economic conditions are good there is a 25% chance the advertising will stimulate further demand and numbers will increase to 25 students.

The profit expected, before deducting the cost of advertising of $15,000, at different levels of student numbers are as follows:

Number of students	Profit in $
15	(10,000)
20	15,000
25	40,000
30	65,000
35	90,000
40	115,000
45	140,000
50	165,000

Required:

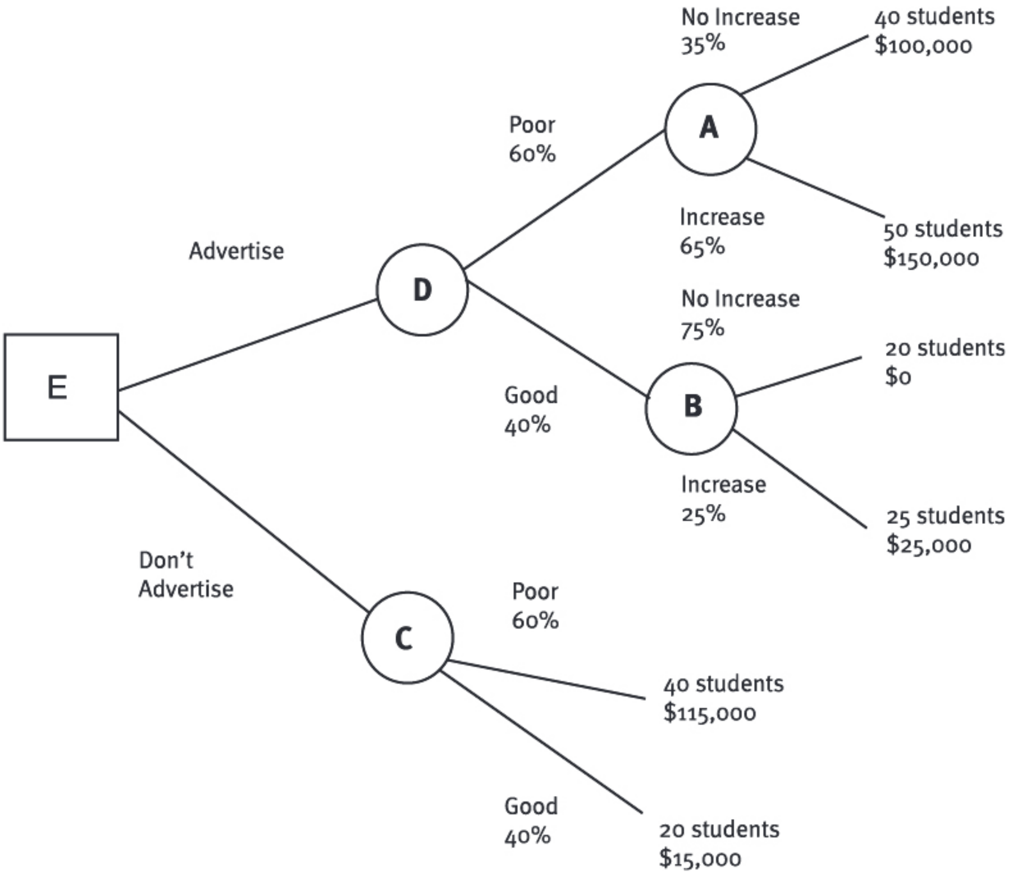
Demonstrate, using a decision tree, whether the programme should be advertised.

Solution

Step 1: Draw the tree from left to right. A **square** is used to represent a decision point (i.e. whether to advertise the programme, or not advertise).

For both options, a **circle** is used to represent a chance point – a poor economic environment, or a good economic environment.

Label the tree and relevant cash inflows/outflows and probabilities associated with outcomes:



Note: The advertising costs have been deducted where relevant in arriving at the figures used on the tree.

For example, the gain for the top right outcome for 40 students = 115,000 – 15,000 = 100,000

Step 2: Evaluate the tree from right to left carrying out these two actions:

(a) Calculate an Expected Value at each outcome point. Working from top to bottom, we can calculate the EVs as follows:

EV (Outcome Point A) = (35% × \$100,000) + (65% × \$150,000) = \$132,500

EV (Outcome Point B) = (75% × $0) + (25% × $25,000) = $6,250

EV (Outcome Point C) = (60% × $115,000) + (40% × $15,000) = $75,000

EV (Outcome Point D) = (60% × $132,500) + (40% × $6,250) = $82,000

(b) Choose the best option at each decision point and **recommend** a course of action to management.

At the first (and only) decision point in our tree (‘E’), we should choose the option to advertise as EV (‘D’) is $82,000 and EV (‘C’) is $75,000.

Test your understanding 3 – The 'Duke of York' cinema

The 'Duke of York' is an independent cinema in Brightville. It is considering whether or not to hire a movie to show in its cinema for one week. If the management decides to hire the movie, it will be screened 20 times during the week. The cost of hiring the movie for the week is $70,000.

You work as the cinema's accountant, and you have been asked to evaluate the financial effects of the decision to hire the movie. You have made the following estimates:

(1) **Customers**

The entrance fee for every customer is $10. The number of customers watching the movie at each screening is uncertain, but has been estimated as follows: there is a 50% probability 200 customers will attend the screening; a 30% probability 250 customers will attend, and 20% probability 150 customers will come.

(2) **Customer contribution for each sale of refreshments**

The average contribution per customer earned from the sale of refreshments is also uncertain but has been estimated as follows:

Probability	**$ average contribution per customer**
40% probability	$10 per customer
25% probability	$12 per customer
35% probability	$8 per customer

Required:

Prepare a decision tree to show the total contributions which could be generated from the above scenario. Based on the expected values, determine if the movie should be hired.

8 The value of perfect information

In many questions the decision makers receive a forecast of a future outcome (for example a market research group may predict the forthcoming demand for a product). This forecast may turn out to be correct or incorrect. The question often requires the candidate to calculate the value of the forecast.

Perfect information The forecast of the future outcome is always a correct prediction. If a firm can obtain a 100% accurate prediction they will always be able to undertake the most beneficial course of action for that prediction.

Imperfect information The forecast is usually correct, but can be incorrect. Imperfect information is not as valuable as perfect information.

The value of information (either perfect or imperfect) may be calculated as follows:

Expected profit (outcome) WITH the information LESS Expected profit (outcome) WITHOUT the information

Illustration 9 – Perfect information

Continuing from the scenario in Illustration 5 earlier, a new ordering system is being considered, whereby customers must order their salad online the day before. With this new system Mr Ramsbottom will know for certain the daily demand 24 hours in advance. He can adjust production levels on a daily basis.

How much is this new system worth to Mr Ramsbottom?

Solution

Supply = demand	X Pay off	P Probability	px
40	$80	0.1	8
50	$100	0.2	20
60	$120	0.4	48
70	$140	0.3	42
			118

E.V. with perfect information = $118

E.V. without perfect information (Working 1) = $90

Value of perfect information $28 per day

Working 1:

According to the pay-off table from Illustration 5, the Expected Value of Profits if **40 salads** are supplied can be calculated as (0.10 × $80) + (0.20 × $80) + (0.40 × $80) + (0.30 × $80) = **$80**.

Likewise:

EV ('**50 salads** daily supply') =	($0 × 10%) =	$0
	+ ($100 × 20%) =	$20
	+ ($100 × 40%) =	$40
	+ ($100 × 30%) =	$30
		$90
EV ('**60 salads** daily supply') =	(– $80 × 10%) =	($8)
	+ ($20 × 20%) =	$4
	+ ($120 × 40%) =	$48
	+ ($120 × 30%) =	$36
		$80
EV ('**70 salads** daily supply') =	(– $160 × 10%) =	($16)
	+ (– $60 × 20%) =	($12)
	+ ($40 × 40%) =	$16
	+ ($140 × 30%) =	$42
		$30

Profits are therefore maximised at 50 salads and amount to $90.

9 The value of imperfect information

Perfect information is only rarely accessible. In fact, information sources such as market research or industry experts are usually subject to error. Market research findings, for example, are likely to be reasonably accurate – but they can still be wrong.

Therefore, our analysis must extend to deal with imperfect information. The question is as follows: **how much would it be worth paying for such imperfect information,** given that we are aware of how right or wrong it is likely to be?

The value of imperfect information

(a) You have the mineral rights to a piece of land that you believe may have oil underground. There is only a 10% chance that you will strike oil if you drill, but the profit is $200,000.

It costs $10,000 to drill. The alternative is not to drill at all, in which case your profit is zero.

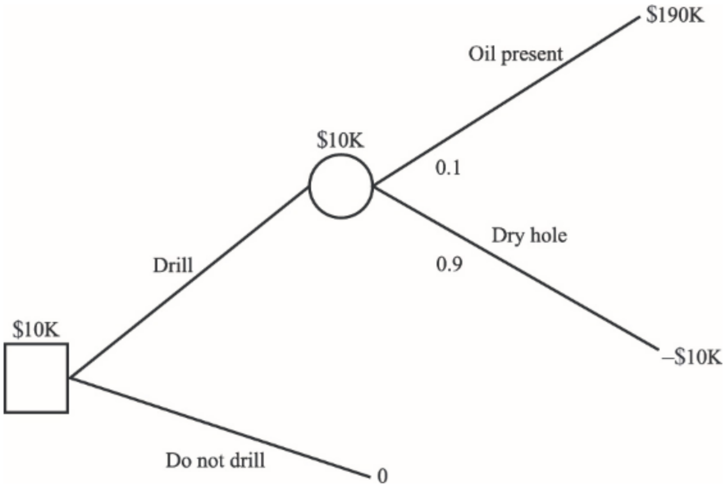
Should you drill? Draw a decision tree to represent your problem.

(b) Before you drill, you may consult a geologist who can assess the promise of the piece of land. She can tell you whether the prospects are good or poor, but she is not a perfect predictor. If there is oil, the probability that she will say there are good prospects is 95%. If there is no oil, the probability that she will say prospects are poor is 85%.

Draw a decision tree and calculate the value of imperfect information for this geologist. If the geologist charges $7,000, would you use her services?

Solution

(a)



EV ('Drill') = ($190K × 0.1) + (–$10K × 0.9) so EV ('Drill') = $10K.

We should drill, because the expected value from drilling is $10K, versus nothing for not drilling.

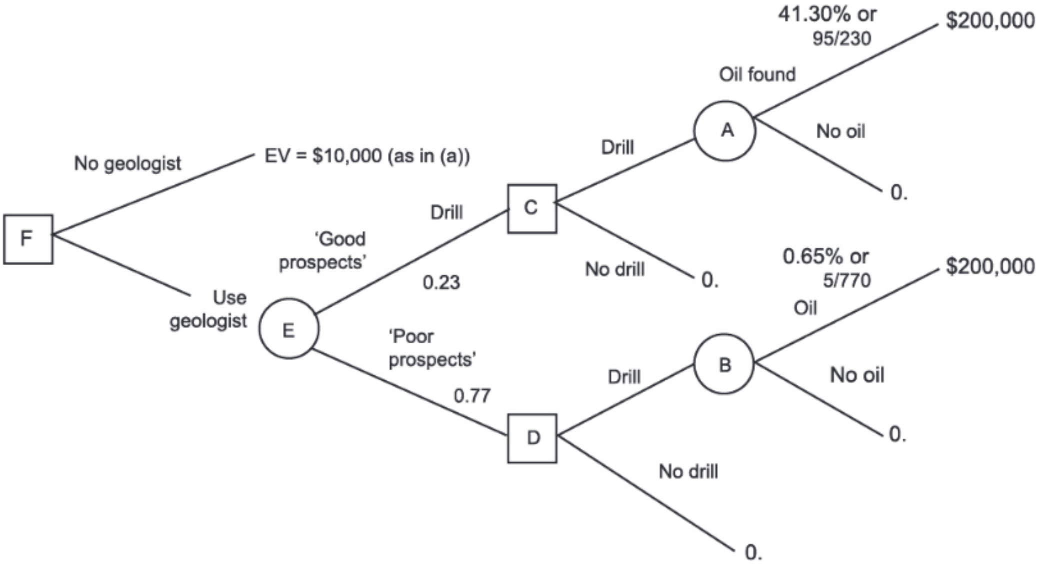
(b) We will calculate the Expected Value of profits if we employ the geologist.

If this exceeds $10,000, the geologist would be worth employing **as long as the benefit of employing her exceeds her charge of $7,000**.

If we employ the geologist, the probabilities of her possible assessments can be tabulated as follows (assume 1,000 drills in total):

	Oil present	**No oil**	**Total**
Geologist says 'Prospects are good'	95% × 100 = 95 drills	15% × 900 = 135 drills	230 drills
Geologist says 'Prospects are poor'	5% × 100 = 5 drills	85% × 900 = 765 drills	770 drills
	100 drills	**900 drills**	**1,000 drills**

A decision tree can be drawn to calculate the expected value of profits if a geologist is employed:



Working from right to left:

EV(A) = (41.30% × $200,000) – $10,000 drilling costs = $72,600.

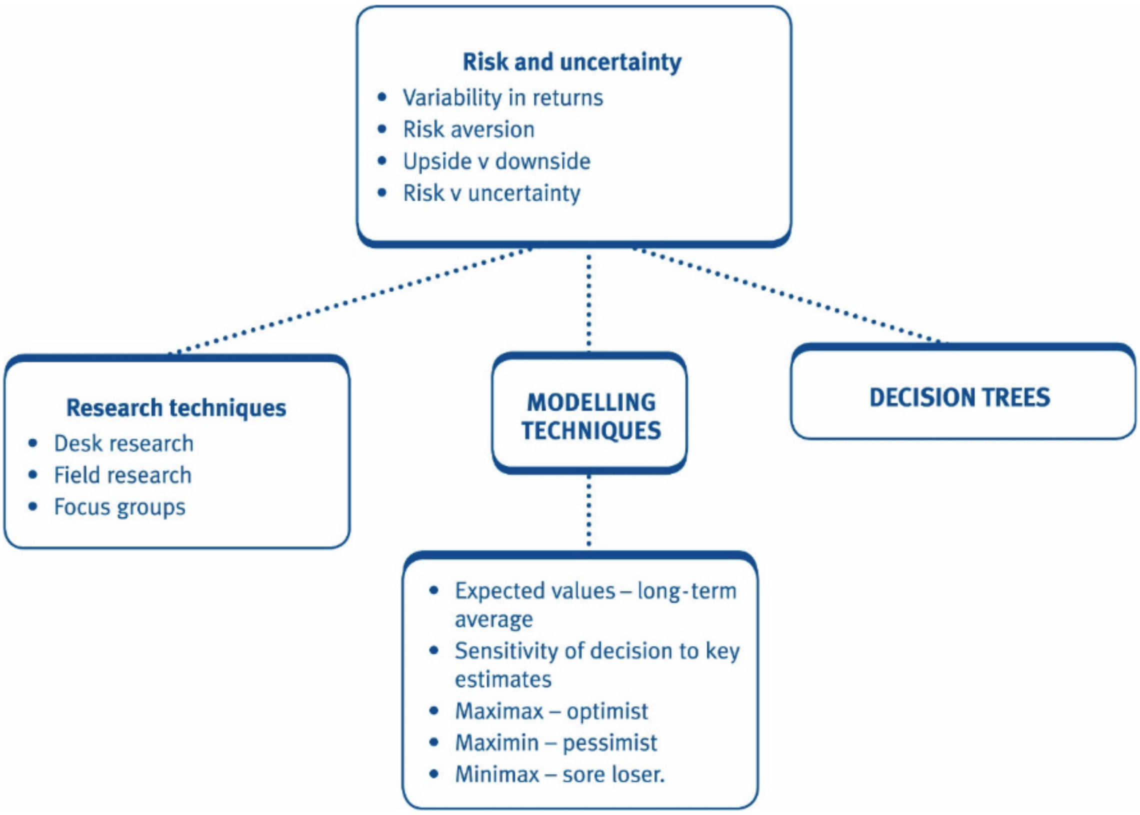
The decision at 'C' should be to drill, as this generates higher benefits than not drilling.

EV(B) = (0.65% × $200,000) – $10,000 drilling costs = –$8,700. The decision at 'D' should be not to drill.

EV(E) = 0.23 × $72,600 = $16,698. This is the expected value of profits if a geologist is employed and exceeds the EV of profits if she is not employed.

Expected Value of Imperfect Information = $16,698 – $10,000 = $6,698. Since this is less than the cost of buying the information ($7,000), we should not employ the geologist at point 'F'.

10 Chapter summary



Test your understanding answers

Test your understanding 1 – Applying maximax

Using maximax, an optimist would consider the best possible outcome for each product and pick the product with the greatest potential.

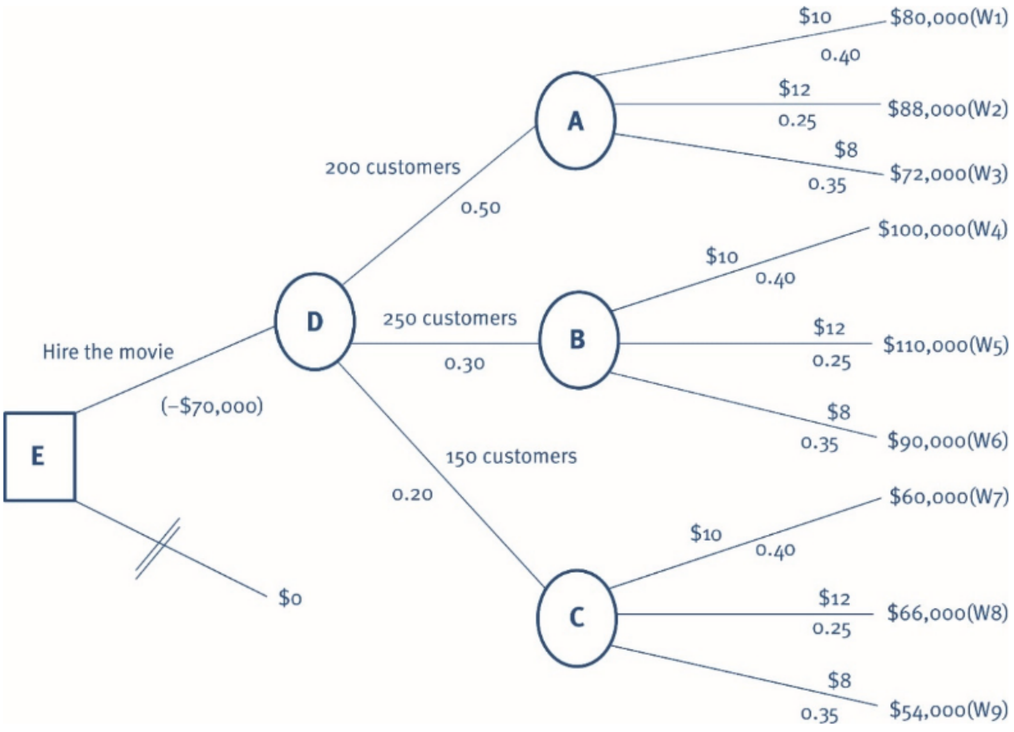
Here C would be chosen with a maximum possible gain of 100.

Test your understanding 2 – Applying maximin

- Using maximin, a pessimist would consider the poorest possible outcome for each product and would ensure that the maximum payoff is achieved if the worst result were to happen.
- Therefore, product A would be chosen resulting in a minimum payoff of 20 compared to a minimum payoff of (70) for B and 10 for C.

Test your understanding 3 – The 'Duke of York' cinema

Step 1: In order to reach a decision about whether or not the movie should be hired, a decision tree could be laid out as follows:



Step 2: Calculate an expected value at each outcome point

EV (Outcome point A) = (40% × $80,000) + (25% × $88,000) + (35% × $72,000) = $79,200

EV (Outcome point B) = (40% × $100,000) + (25% × $110,000) + (35% × $90,000) = $99,000

EV (Outcome point C) = (40% × $60,000) + (25% × $66,000) + (35% × $54,000) = $59,400

EV (Outcome point D) = (50% × $79,200) + (30% × $99,000) + (20% × $59,400) = $81,180

Step 3: Choose the best option at each decision point and recommend a course of action to management

At the first and only decision point in our tree 'E', we should choose the option to hire the movie as EV (D) is equal to a positive contribution of $11,180 (See Working 10) and not hiring the movie does not generate any contribution at all.

Contribution generated – Workings

We can calculate those customers × 20 screenings × ($10 entrance fee + refreshment contribution)

W1: 200 × 20 × ($10 + $10) = $80,000

W2: 200 × 20 × ($10 + $12) = $88,000

W3: 200 × 20 × ($10 + $8) = $72,000

W4: 250 × 20 × ($10 + $10) = $100,000

W5: 250 × 20 × ($10 + $12) = $110,000

W6: 250 × 20 × ($10 + $8) = $90,000

W7: 150 × 20 × ($10 + $10) = $60,000

W8: 150 × 20 × ($10 + $12) = $66,000

W9: 150 × 20 × ($10 + $8) = $54,000

W10: Contribution if the movie is hired is calculated as EV ('D') $81,180 – $70,000 cost of hiring = $11,180.

Chapter

10

Budgeting

Chapter learning objectives

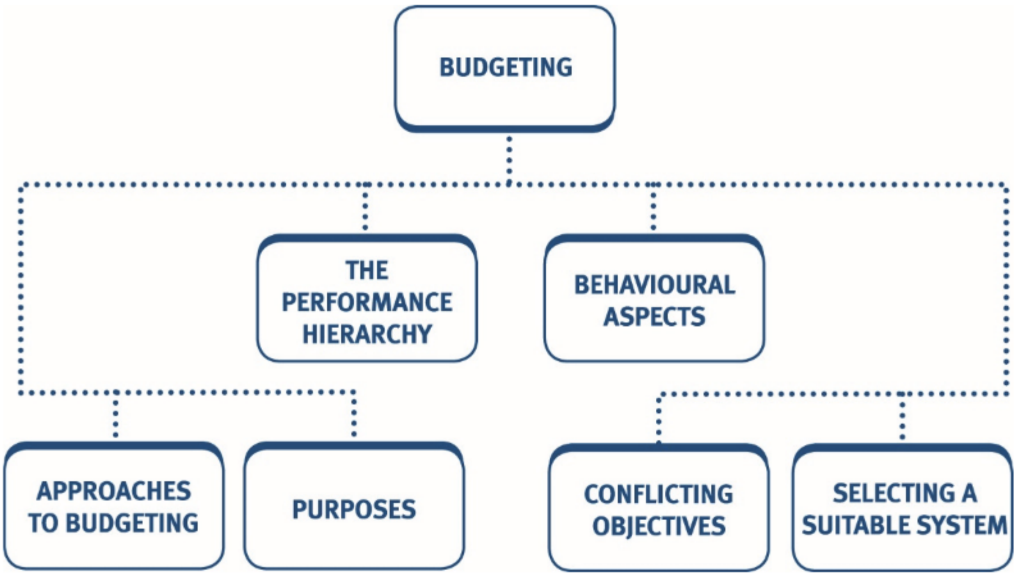
Upon completion of this chapter, you will be able to:

- Explain how budgetary systems fit within the performance hierarchy.
- Select and explain appropriate budgetary systems for an organisation, including top-down, bottom-up, rolling, zero-based, activity-based, incremental and feed-forward control.
- Describe the information used in budget systems and the sources of the information needed.
- Indicate the usefulness and problems with different budget types (including fixed, flexible, zero-based, activity-based, incremental, rolling, top-down, bottom-up, master, functional).
- Explain and illustrate the importance of flexing budgets in performance management.
- Prepare flexed budgets (see chapter 1), rolling budgets and activity-based budgets.
- Explain the beyond budgeting model, including the benefits and problems that may be faced if it is adopted in an organisation.
- Discuss the issues surrounding setting the difficulty level for a budget.
- Explain the benefits and difficulties of the participation of employees in the negotiation of targets.
- Explain and apply the principle of controllability in the performance management system.

- Explain the difficulties of changing a budgetary system or type of budget used.
- Explain how budget systems can deal with uncertainty in the environment.
- Discuss ethical and sustainability considerations when setting budgets.

PER

One of the PER performance objectives (PO13) is to plan business activities and control performance, making recommendations for improvement. Working through this chapter should help you understand how to demonstrate that objective.



1 Purpose of budgets

A budget is a quantitative plan prepared for a specific time period. It is normally expressed in financial terms and prepared for one year.

Budgeting serves a number of purposes:

- **Planning**

  A budgeting process forces a business to look to the future. This is essential for survival since it stops management from relying on ad hoc or poorly co-ordinated planning.

- **Control**

  Actual results are compared against the budget and action is taken as appropriate.

- **Communication**

  The budget is a formal communication channel that allows junior and senior managers to converse.

- **Co-ordination**

  The budget allows co-ordination of all parts of the business towards a common corporate goal.

- **Evaluation**

  Responsibility accounting divides the organisation into budget centres, each of which has a manager responsible for its performance. The budget may be used to evaluate the actions of a manager within the business in terms of the costs and revenues over which they have control.

- **Motivation**

  The budget may be used as a target for managers to aim for. Reward should be given for operating within or under budgeted levels of expenditure. This acts as a motivator for managers.

- **Authorisation**

  The budget acts as a formal method of authorisation to a manager for expenditure, hiring staff and the pursuit of plans contained within the budget.

- **Delegation**

  Managers may be involved in setting the budget. Extra responsibility may motivate the managers. Management involvement may also result in more realistic targets.

2 Budgets and performance management

Budgets contribute to performance management by providing benchmarks against which to compare actual results (through variance analysis), and develop corrective measures. They take many forms and serve many functions, but most provide the basis for:

- detailed sales targets
- staffing plans
- production
- cash investment and borrowing
- capital expenditure.

Budgets give managers "preapproval" for execution of spending plans, and allow them to provide forward looking guidance to investors and creditors. For example, budgets are necessary to convince banks and other lenders to extend credit.

Even in a small business, an robust business plan/budget can often result in anticipating and avoiding disastrous outcomes.

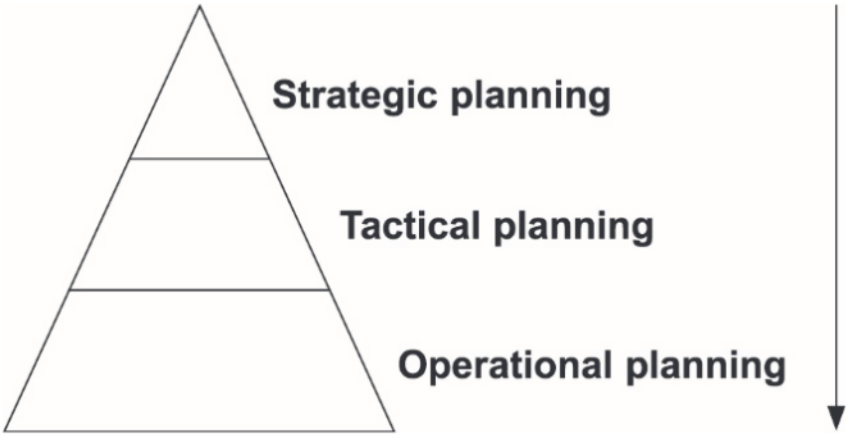
Medium and larger organisations invariably rely on budgets. This is equally true in businesses, government, and not-for-profit organisations. The budget provides a formal quantitative expression of expectations. It is an essential facet of the planning and control process. Without a budget, an organisation will be highly inefficient and ineffective.

Test your understanding 1 – Evaluation of managers

A wage award for production staff is agreed which exceeds the allowance incorporated in the budget. Discuss whether the performance of the production manager should be linked to the wage cost.

3 The performance hierarchy

Firms have a planning hierarchy:



- Strategic planning is long term, looks at the whole organisation and defines resource requirements. For example, to develop new products in response to changing customer needs.
- Tactical planning is medium term, looks at the department/divisional level and specifies how to use resources. For example, to train staff to deal with the challenges that this new product presents.
- Operational planning is very short term, very detailed and is mainly concerned with control. Most budgeting activities fall within operational planning and control. For example, a budget is set for the new product to include advertising expenditure, sales forecasts, labour and material expenditure etc.

The aim is that if a manager achieves short-term budgetary targets (operational plans) then there is more chance of meeting tactical goals and ultimately success for strategic plans.

The achievement of budgetary plans will impact on the eventual achievement of the tactical and strategic plans. However, budgets should also be flexible in order to meet the changing needs of the business.

Budgets that are prepared for manufacturing organisations typically include sales, production, materials usage, materials purchases, and labour utilisation, together with other budgets including various functional (including departmental) budgets, capital expenditure budgets and cash budgets. These are co-ordinated and amalgamated to form a set of master Budgets.

4 Behavioural aspects of budgeting

Individuals react to the demands of budgeting and budgetary control in different ways and their behaviour can damage the budgeting process.

Behavioural problems are often linked to management styles, and include dysfunctional behaviour and budget slack.

Management styles (Hopwood)

Research was carried out by Hopwood (1973) into the manufacturing division of a US steelworks, involving a sample of more than 200 managers with cost centre responsibility. Hopwood identified three distinct styles of using budgetary information to evaluate management performance.

Management style	**Performance evaluation**	**Behavioural aspects**
(1) Budget constrained style	• Manager evaluated on ability to achieve budget in the short term • Manager will be criticised for poor results. For example, if spending exceeds the limit set	• Job related pressure • May result in short-term decision making at the expense of long term goals Can result in poor working relations with colleagues • Can result in manipulation of data
(2) Profit conscious style	• Manager evaluated on ability to reduce costs and increase profit in the long term • For example, a manager will be prepared to exceed the budgetary limit in the short term if this will result in an increase in long term profit	• Less job related pressure • Better working relations with colleagues • Less manipulation of data
(3) Non-accounting style	• Manager evaluated mainly on non-accounting performance indicators such as quality and customer satisfaction	• Similar to profit conscious style but there is less concern for accounting information • Requires significant and stringent monitoring of performance against budget

5 Setting the difficulty level of a budget

Budgetary targets will assist motivation and appraisal if they are at the right level.

An **expectations** budget is a budget set at current achievable levels. This is unlikely to motivate managers to improve but may give more accurate forecasts for resource planning, control and performance evaluation.

An **aspirations** budget is a budget set at a level which exceeds the level currently achieved. This may motivate managers to improve if it is seen as attainable but may also result in an adverse variance if it is too difficult to achieve. This must be managed carefully.

Test your understanding 2

A manager is awarded a bonus for achieving monthly budgetary targets. State three possible behavioural implications of this policy. What should be done to try to improve the process?

Test your understanding 3

A sales manager has achieved $550,000 of sales in the current year. Business is expected to grow by 10% and price inflation is expected to be 3%.

Suggest a suitable budget target for the forthcoming year.

6 Approaches to budgeting

There are a number of different budgetary systems:

- Top down vs bottom up budgeting
- Incremental budgeting
- Zero-based budgeting (ZBB)
- Rolling budgets
- Activity-based budgeting
- Feed-forward control.

Each system will be reviewed in turn.

7 Budgeting and participation

There are basically two ways in which a budget can be set: from the top down (imposed budget) or from the bottom up (participatory budget).

Imposed style

An imposed/top-down budget is 'a budget allowance which is set without permitting the ultimate budget holder to have the opportunity to participate in the budgeting process'

Advantages of imposed style

There are a number of reasons why it might be preferable for organisations to choose the top-down approach to budgeting, as opposed to the bottom-up style. The following are advantages of the imposed style, but also some of these are reasons why the bottom-up style can be less useful in comparison.

(1) Involving managers in the setting of budgets is more time consuming than if senior managers simply imposed the budgets.

(2) Managers may not have the skills or motivation to participate usefully in the budgeting process.

(3) Senior managers have the better overall view of the company and its resources and may be better-placed to create a budget which utilises those scarce resources to best effect.

(4) Senior managers also are aware of the longer term strategic objectives of the organisation and can prepare a budget which is in line with that strategy.

(5) Budget holders may build budgetary slack or bias into the budget in order to make the budget easy to achieve and themselves look good.

(6) By having the budgets imposed by senior managers, i.e. someone outside the department, a more objective, fresher perspective may be gained.

(7) If the participation is only pseudo-participation and the budgets are frequently drastically changed by senior management, then this will cause dissatisfaction and the effect will be to demotivate staff.

Participative budgets

Participative/bottom up budgeting is 'A budgeting system in which all budget holders are given the opportunity to participate in setting their own budgets'

Advantages of participative budgets

The following are advantages of the bottom-up style, but, again, these are also some of these are reasons why the top-down style can be less useful in comparison.

(1) The morale of the management is improved. Managers feel like their opinion is listened to, that their opinion is valuable.

(2) Managers are more likely to accept the plans contained within the budget and strive to achieve the targets if they had some say in setting the budget, rather than if the budget was imposed upon them. Failure to achieve the target that they themselves set is seen as a personal failure as well as an organisational failure.

(3) The lower level managers will have a more detailed knowledge of their particular part of the business than senior managers and thus will be able to produce more realistic budgets.

(4) It frees up senior management time as the budget holders are doing most of the work.

Budgetary control – Behavioural aspects

Another very important aspect of budgetary control systems and this is its impact on the human beings who will operate and be judged by those systems.

It is only comparatively recently that the results of years of study of personal relationships in the workplace have percolated into the field of management accounting. It is now recognised that failure to consider the effect of control systems on the people affected could result in a lowering of morale and a reduction of motivation. Further, those people may be induced to do things that are not in the best interests of the organisation.

Specific behavioural issues encountered in budgeting include the following:

Motivation and co-operation

To be fully effective, any system of financial control must provide for motivation and incentive. If this requirement is not satisfied, managers will approach their responsibilities in a very cautious and conservative manner. It is often found that adverse variances attract investigation and censure but there is no incentive to achieve favourable variances. Failure to distinguish controllable from uncontrollable costs in budgetary control can alienate managers from the whole process.

Personal goals and ambitions are, in theory, strongly linked to organisational goals. These personal goals may include a desire for higher income and higher social standing. To simultaneously satisfy the goals of the organisation and the goals of the individual there must be 'goal congruence'. That is, the individual manager perceives that his or her own goals are achieved by his or her acting in a manner that allows the organisation to achieve its goals. The problem is that reliance on budgetary control systems does not always result in goal congruence.

The success of a budgetary control system depends on the people who operate and are affected by it. They must work within the system in an understanding and co-operative manner. This can only be achieved by individuals who have a total involvement at all stages in the budget process. However, it is often found that

(1) A budget is used simply as a pressure device. If the budget is perceived as 'a stick with which to beat people', then it will be sabotaged in all sorts of subtle ways.

(2) The budgeting process and subsequent budgetary control exercises induce competition between individual departments and executives. Managers may be induced to do things in order to 'meet budget' that are not in the best interests of the business as a whole.

Failure of goal congruence

It has been seen that an essential element in budgetary control is performance evaluation. Actual results are compared with budget or standard in order to determine whether performance is good or bad.

What is being evaluated is not just the business operation but the managers responsible for it. The purpose of budgetary control is to induce managers to behave in a manner that is to the best advantage of the organisation. Compliance with budget is enforced by a variety of negative and positive sanctions.

When adverse variances are reported for operations then this implies poor performance by the managers of the operations. If they are unable to correct or explain away the adverse variances, then they may suffer negative sanctions. They may have to forgo salary increases, or they may be demoted to a less prestigious post. Other more subtle negative sanctions are possible that anyone who has ever worked for a large organisation will be aware of.

Positive inducements may be offered to encourage managers to avoid adverse variances. A manager who meets budget may be granted a performance-related salary bonus, promotion, a new company car or use of the executive dining room.

Consequently, the manager has a considerable incentive to ensure that the department or operation they are responsible for achieves its budgeted level of performance. However, there are a variety of ways of doing this that might not be to the advantage of the organisation as a whole.

For example, the manager of a production line can cut costs and hence improve its reported performances by reducing quality controls. This may result in long-term problems concerning failure of products in service, loss of customer goodwill and rectification costs – but these are not the concern of the production line manager. This is a clear failure of goal congruence.

The control system is capable of distorting the process it is meant to serve – or ‘the tail wags the dog’. The enforcement of a budgetary control system requires sensitivity if this is not to happen.

The budget as a pot of cash

In some environments managers may come to consider the budget as a sum of money that has to be spent. This arises particularly in service departments or public sector organisations, the performance of which is gauged mainly through comparison of actual and budget spending.

The manager of a local authority ‘street cleaning’ department may be given an annual budget of $120,000 to clean the streets. The manager knows that they will be punished if they spend more than $120,000 in the year. They also know that if they spend less than $120,000 in the year then their budget will probably be reduced next year. Such a reduction will involve a personal loss of status in the organisation and will make their job more difficult in the next year.

In order to ensure that they do not overspend their annual budget in the current year the manager may spend at a rate of $9,000 per month for the first 11 months of the year. This can be achieved by reducing the frequency of street cleaning and using poor-quality materials. It allows a contingency fund to be accumulated in case of emergencies.

However, in the final month of the year the manager has to spend $21,000 if they wish to ensure that their whole budget is fully used. They might achieve this by using extra labour and high-quality materials.

Does this behaviour make sense? Of course it does not. The whole pattern of behaviour is distorted by the control system. It means that local residents have a substandard service for 11 months of the year and money is wasted in the 12th month.

It is, however, a fact that suppliers to government departments and local councils often experience a surge in orders towards the end of the financial year. This surge is caused by managers placing orders at the last moment in order to ensure that their full budget for the year is committed.

Budget negotiation

Budgets are normally arrived at by a process of negotiation with the managers concerned. A budget may actually be initiated by departmental managers and then corrected as a result of negotiation with the budget officer.

Clearly, a manager has an incentive to negotiate a budget that is not difficult to achieve. This produces a phenomenon known as ‘padding the budget’ or ‘budgetary slack’. A manager will exaggerate the costs required to achieve objectives.

(1) If the manager succeeds in padding their budget, then the whole control exercise is damaged. Comparison of actual with budget gives no meaningful measure of performance and the manager is able to include inefficiencies in their operation if they wish.

(2) A successful manager becomes one who is a hard negotiator. The problem with this is that the negotiations in question are between colleagues and not with customers. ‘Infighting’ may become entrenched in the management process.

(3) A great deal of time and energy that could be directed to the actual management of the business is distracted by what are essentially administrative procedures.

These are all examples of a control system distorting the processes they are meant to serve.

Influence on accounting policies

Any management accountant who has been engaged in the preparation of financial control reports will be familiar with attempts by managers to influence the accounting policies that are used. For example, the apportionment of indirect costs between departments often contains subjective elements. Should security costs be apportioned on the basis of floor space or staff numbers?

The manner in which the indirect costs are apportioned can have a considerable impact on how the performance of individual departments is perceived. This position creates the scope and incentive for managers to argue over accounting policies.

If a manager perceives that their department's performance is falling below budget, then they may sift through the costs charged to their department and demand that some be reclassified and charged elsewhere. The time and energy that goes into this kind of exercise has to be diverted from that available for the regular management of the business.

Budget constrained management styles

When the performance of a manager is assessed by their ability to meet budget, then they are likely to adopt a conservative approach to new business opportunities that appear. The immediate impact of new business ventures is likely to be a rise in capital and operating costs – with an adverse impact on current period profit. The benefits of such ventures may only be felt in the long term. Hence, when a new opportunity appears, the manager evaluating it may only perceive that its acceptance will result in below-budget performance in the current period – and turn it down on this ground alone. Another consideration is that reliance on budgetary control is an approach to management that involves sitting in an office and reading financial reports. Such an approach (in conjunction with features such as executive dining rooms) may result in an unsatisfactory corporate culture based on hierarchies and social divisions. Large organisations that rely heavily on budgetary control systems often take on an 'ossified' character.

Yet another consideration is that a reliance on budgetary planning may induce managers to favour projects and developments that are most amenable to the construction of budgets. Projects that involve little uncertainty and few unknowns are easy to incorporate in budgets and hence managers may be more inclined to adopt such projects than the alternatives. Projects that involve significant uncertainties may be attractive if they incorporate some combination of high expected returns and low cost interim exit routes – but a budget constrained manager may be disinclined to adopt such projects simply because they are difficult to incorporate in budgets. Some writers suggest that the budgetary approach may be particularly inappropriate in a dynamic and turbulent business environment.

The general conclusion concerning this and previous points is that good budgetary control can offer certain benefits. However, when budgetary control is enforced in a rigid or insensitive manner it may end up doing more harm than good.

Budgets and motivation

Much of the early academic work on budgets concerned the extent to which the 'tightness' or looseness' of a budget acted as an incentive or disincentive to management effort. This was the issue of 'budget stretch'. Seminal works in this general area included studies by A.C. Stedry (see his 1960 text 'Budget Control and Cost Behaviour') and G.H. Hofstede (see his 1968 text 'The Game of Budget Control').

The main thrust of the findings that emerged from these studies was:

(1) Loose budgets (i.e. ones easily attainable) are poor motivators

(2) As budgets are tightened, up to a point they become more motivational

(3) Beyond that point, a very tight budget ceases to be motivational.

The role of budget participation and the manner in which aspirations and objectives are stated was also explored in certain studies. It was suggested that the participation of managers in budget setting was a motivational factor – but see earlier discussion concerning budget padding and negotiation.

Test your understanding 4

Bottom up budgeting is generally seen as preferable because it leads to improved managerial motivation and performance. However, there are situations for which top down budgeting is preferable.

Describe three situations where top down budgeting would be more applicable.

Incremental budgets

An incremental budget starts with the previous period's budget or actual results and adds (or subtracts) an incremental amount to cover inflation and other known changes.

It is suitable for stable businesses, where costs are not expected to change significantly. There should be good cost control and limited discretionary costs.

Advantages of incremental budgets	Disadvantages of incremental budgets
(1) Quickest and easiest method.	(1) Builds in previous problems and inefficiencies.
(2) Suitable if the organisation is stable and historic figures are acceptable since only the increment needs to be justified.	(4) Uneconomic activities may be continued. E.g. the firm may continue to make a component in-house when it might be cheaper to outsource.
(3) Managers will not be demotivated by targets changing regularly.	(3) Managers may spend unnecessarily to use up their budgeted expenditure allowance this year, thus ensuring they get the same (or a larger) budget next year.

Test your understanding 5

AW Inc produces two products, A and C. In the last year (20X4) it produced 640 units of A and 350 units of C incurring costs of $672,000. Analysis of the costs has shown that 75% of the total costs are variable. 60% of these variable costs vary in line with the number of A produced and the remainder with the number of C.

The budget for the year 20X5 is now being prepared using an incremental budgeting approach. The following additional information is available for 20X5:

- All costs will be 4% higher than the average paid in 20X4.
- Efficiency levels will remain unchanged.
- Expected output of A is 750 units and of C is 340 units.

What is the budgeted total variable cost of products A and C for the full year 20X5?

Zero-based budgeting

A ‘method of budgeting that requires each cost element to be specifically justified, as though the activities to which the budget relates were being undertaken for the first time. Without approval, the budget allowance is zero’

It is suitable for:

- allocating resources in areas were spend is discretionary, i.e. non-essential. For example, research and development, advertising and training.
- public sector organisations such as local authorities.

There are four distinct stages in the implementation of ZBB:

(1) Managers should specify, for their responsibility centres, those activities that can be individually evaluated.

(2) Each of the individual activities is then described in a decision package. The decision package should state the costs and revenues expected from the given activity. It should be drawn up in such a way that the package can be evaluated and ranked against other packages.

(3) Each decision package is evaluated and ranked usually using cost/benefit analysis.

(4) The resources are then allocated to the various packages.

Advantages of ZBB	**Disadvantages of ZBB**
(1) Inefficient or obsolete operations can be identified and discontinued	(1) It emphasises short-term benefits to the detriment of long-term goals
(2) ZBB leads to increased staff involvement at all levels since a lot more information and work is required to complete the budget	(2) The budgeting process may become too rigid and the organisation may not be able to react to unforeseen opportunities or threats
(3) It responds to changes in the business environment	(3) The management skills required may not be present
(4) Knowledge and understanding of the cost behaviour patterns of the organisation will be enhanced	(4) Managers may feel demotivated due to the large amount of time spent on the budgeting process
(5) Resources should be allocated efficiently and economically	(5) Ranking can be difficult for different types of activities or where the benefits are qualitative in nature

Additional information on decision packages

A decision package was defined by Peter Pyhrr (who first formulated the ZBB approach at Texas Instruments) as:

A document that identifies and describes a specific activity in such a manner that senior management can:

(a) evaluate and rank it against other activities competing for limited resources, and

(b) decide whether to approve or disapprove it.’

A decision package is a document that:

- analyses the cost of the activity (costs may be built up from a zero base, but costing information can be obtained from historical records or last year's budget)
- states the purpose of the activity
- identifies alternative methods of achieving the same purpose
- assesses the consequence of not doing the activity at all, or performing the activity at a different level
- establishes measures of performance for the activity.

Pyhrr identifies two types of package.

(i) Mutually exclusive packages: these contain different methods of obtaining the same objective.

(ii) Incremental packages: these divide the activity into a number of different levels of activity. The base package describes the minimum effort and cost needed to carry out the activity. The other packages describe the incremental costs and benefits when added to the base.

For example, a company is conducting a ZBB exercise, and a decision package is being prepared for its materials handling operations.

- The manager responsible has identified a base package for the minimum resources needed to perform the materials handling function. This is to have a team of five workers and a supervisor, operating without any labour-saving machinery. The estimated annual cost of wages and salaries, with overtime, would be $375,000.
- In addition to the base package, the manager has identified an incremental package. The company could lease two fork lift trucks at a cost of $20,000 each year. This would provide a better system because materials could be stacked higher and moved more quickly. Health and safety risks for the workers would be reduced, and there would be savings of $5,000 each year in overtime payments.
- Another incremental package has been prepared, in which the company introduces new computer software to plan materials handling schedules. The cost of buying and implementing the system would be $60,000, but the benefits are expected to be improvements in efficiency that reduce production downtime and result in savings of $10,000 each year in overtime payments.

The base package would be considered essential, and so given a high priority. The two incremental packages should be evaluated and ranked. Here, the fork lift trucks option might be ranked more highly than the computer software.

In the budget that is eventually decided by senior management, the fork lift truck package might be approved, but the computer software package rejected on the grounds that there are other demands for resources with a higher priority.

Test your understanding 6

For a number of years, the research division of Z Inc has produced its annual budget (for new and continuing projects) using incremental budgeting techniques. The company is now under new management and the annual budget for 20X4 is to be prepared using ZBB techniques.

Explain how Z Inc could operate a ZBB system for its research projects.

ZBB and incremental budgeting in the public sector

The process of identifying decision packages and determining their purpose, costs and benefits is massively time consuming and costly.

One solution to this problem is to use incremental budgeting every year, and then use ZBB every three to five years, or when major change occurs. This means that an organisation can benefit from some of the advantages of ZBB without an annual time and cost implication.

Another option is to use ZBB for some departments but not for others. Certain costs are essential rather than discretionary and it could be argued that it is pointless to carry out ZBB in relation to these. For example, heating and lighting costs in a school or hospital are expenses that will have to be paid, irrespective of the budget amount allocated to them. Incremental budgeting would seem to be more suitable for costs like these, as with building repair costs.

Rolling budgets

A budget (usually annual) kept continuously up to date by adding another accounting period (e.g. month or quarter) when the earliest accounting period has expired. The remaining budget is re-forecast, as well as the new period being added.

Rolling budgets are suitable if accurate forecasts cannot be made (for example, in a fast moving environment), or for any area of business that needs tight control.

Illustration 1 – Rolling budgets

A typical rolling budget might be prepared as follows:

(1) A budget is prepared for the coming year (say January – December) broken down into suitable, say quarterly, control periods.

(2) At the end of the first control period (31 March) a comparison is made of that period's results against the budget. The conclusions drawn from this analysis are used to update the budgets for the remaining control periods and to add a budget for a further three months, so that the company once again has budgets available for the coming year (this time April – March).

(3) The planning process is repeated at the end of each three-month control period.

Advantages of rolling budgets	Disadvantages of rolling budgets
(1) Planning and control will be based on a more accurate budget	(1) Rolling budgets are more costly and time consuming than incremental budgets
(2) Rolling budgets reduce the element of uncertainty in budgeting since they concentrate on the short-term when the degree of uncertainty is much smaller	(2) May demotivate employees if they feel that they spend a large proportion of their time budgeting or if they feel that the budgetary targets are constantly changing
(3) There is always a budget that extends into the future (normally 12 months)	(3) There is a danger that the budget may become the last budget 'plus or minus a bit'
(4) It forces management to reassess the budget regularly and to produce budgets which are more up to date	(4) An increase in budgeting work may lead to less control of the actual results
	(5) Issues with version control, as each month the full year numbers will change
	(6) Confusion in meetings as to each numbers the business is working towards; this can distract from the key issues. as managers discuss which numbers to achieve

Test your understanding 7

A company uses rolling budgeting and has a sales budget as follows:

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
	$	$	$	$	$
Sales	125,750	132,038	138,640	145,572	542,000

Actual sales for Quarter 1 were $123,450. The adverse variance is fully explained by competition being more intense than expected and growth being lower than anticipated. The budget committee has proposed that the revised assumption for sales growth should be 3% per quarter.

Update the budget as appropriate.

Test your understanding 8

Broad Co produces quarterly rolling budgets and had forecast the costs of material purchases for the next four quarters (quarters 1, 2, 3 and 4). Purchases for quarter 1 were budgeted to be $220,000 and it was anticipated that the cost of materials would rise at a rate of 2% per quarter.

At the end of quarter 1:

Actual material purchases were recorded as $210,000. This was due to a change of material supplier during the quarter.

- A revised estimate for the increase in material purchase costs was made. The rise was now predicted to be only 1% per quarter.
- The budget was updated.

What estimate for total annual material purchases should be recorded in the updated budget (to the nearest whole $)?

Activity Based Budgeting

ABB is defined as: 'a method of budgeting based on an activity framework and utilising cost driver data in the budget-setting and variance feedback processes'

Or, put more simply, preparing budgets using overhead costs from activity based costing methodology.

Test your understanding 9 – Preparing an ABB

The operating divisions of Z Co have in the past always used a traditional approach to analysing costs into their fixed and variable components. A single measure of activity was used which, for simplicity, was the number of units produced. The new management accountant does not accept that such a simplistic approach is appropriate for budgeting in the modern environment and has requested that the managers adopt an activity based approach in future.

Required:

Explain how ABB would be implemented by the operating divisions of Z Co.

The advantages of ABB are similar to those provided by activity-based costing (ABC).

- It draws attention to the costs of 'overhead activities' which can be a large proportion of total operating costs.
- It recognises that it is activities which drive costs. If we can control the causes (drivers) of costs, then costs should be better managed and understood.
- ABB can provide useful information in a total quality management (TQM) environment, by relating the cost of an activity to the level of service provided.

Disadvantages of ABB

- A considerable amount of time and effort might be needed to establish the key activities and their cost drivers.
- It may be difficult to identify clear individual responsibilities for activities.
- It could be argued that in the short-term many overhead costs are not controllable and do not vary directly with changes in the volume of activity for the cost driver. The only cost variances to report would be fixed overhead expenditure variances for each activity.

Activity matrix

An activity-based budget can be constructed by preparing an activity matrix. This identifies the activities in each column, and the resources required to carry out the activities in each row.

The following 'activity matrix' shows the resources used (rows) and major functions/activities (columns) of a stores department. In this example, all the identified activities occur within a single department.

- The total current annual costs of each resource consumed by the department are shown in the final column; they have then been spread back over the various activities to establish the cost pools. The allocation of resource costs between activities will, to some extent, be subjective.
- Each of the first four activities has an identifiable cost driver, and the total resource cost driver rates can be determined (cost per unit of activity).
- The last two activities that occur within the department are non-volume related, and are sometimes referred to as 'sustaining costs'. They are necessary functions and should not be ignored in the budgeting process; however, they should not be attributed to particular cost drivers, as this would not reflect their true cost behaviour and would result in inappropriate budgets being set.

Activity cost matrix for stores department

Activity:	**Receiving deliveries**	**Issuing from store**	**Stock ordering**	**Stock counting**	**Keeping records**	**Supervision**	**Total**
Cost driver:	Deliveries	Store requisitions	Number of orders	Number of counts	–	–	
Number:	400	800	400	12			
	$000	$000	$000	$000	$000	$000	$000
Management salary	–	–	–	1	4	25	30
Basic wages	20	25	6	4	11	–	66
Overtime payments	5	–	–	5	5	–	
Stationery, etc.	1	2	2	1	3	–	9
Other	6	5	2	1	1	5	20
Total	**32**	**32**	**10**	**12**	**24**	**30**	**140**
Cost per activity unit	$80	$40	$25	$1,000			

Sustaining costs will effectively be treated as fixed costs. However, for control purposes, activity-based costs can be assumed to be variable, and actual costs can be compared with the expected costs for the given level of activity.

Test your understanding 10

Which statement is correct regarding the benefits to be gained from using ABB?

A If there is much inefficiency within the operations of a business then ABB will identify and remove these areas of inefficiency.

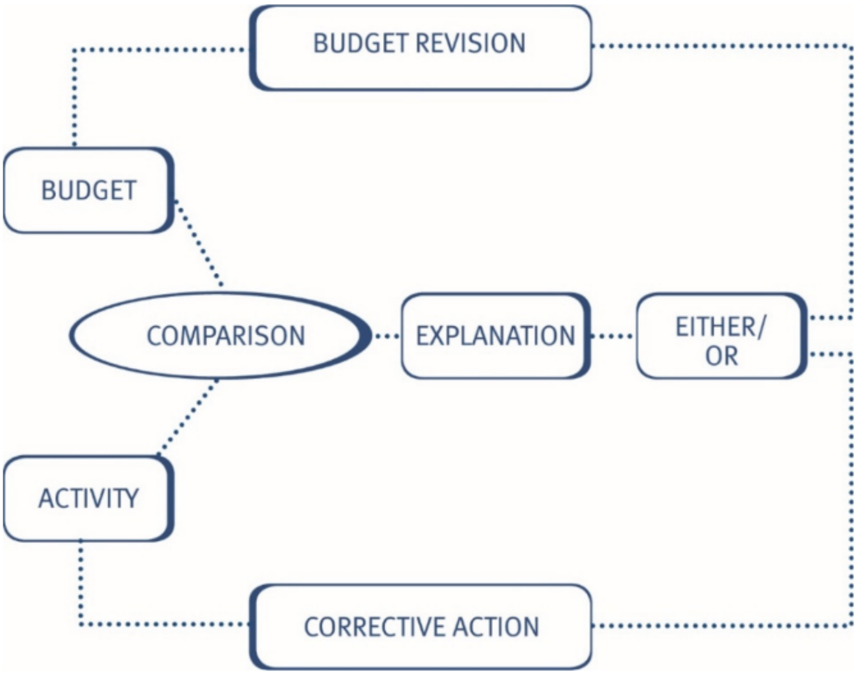
B In a highly direct labour intensive manufacturing process, an ABB approach will assist management in budgeting for the majority of the production costs.

C In an organisation currently operating efficiently, where the next period will be relatively unchanged from the current one, then ABB will make the budgeting process simpler and quicker.

D If an organisation produces many different types of output using different combinations of activities then ABB can provide more meaningful information for budgetary control.

8 Feedback control

Feedback control is defined as 'the measurement of differences between planned outputs and actual outputs achieved, and the modification of subsequent action and/or plans to achieve future required results'. This is the most common type of control system.



Positive feedback is feedback taken to reinforce a deviation from standard. The inputs or processes would not be altered.

Negative feedback is feedback taken to reverse a deviation from standard. This could be by amending the inputs or process, so that the system reverts to a steady state. For example, a machine may need to be reset over time to its original settings.

Single/Double loop feedback

Single loop feedback is control which regulates the output of a system. It involves connecting a strategy for action with a result. For example, if an action we take yields results that are different to what we expected ('target costs are not achieved'), through single-loop feedback, we will observe the results, automatically take in feedback, and try a different approach to achieve targets. However, we don't try and change the targets.

Double loop feedback occurs when a business is able, having attempted to achieve a target (say, for sales volume) on different occasions, to modify the target or budget in the light of experience, or possibly even reject the target.

9 Feedforward control

A feedforward control system operates by comparing budgeted results against a forecast. Control action is triggered by differences between budgeted and forecast results.

Feedforward control is control based on forecast results. In other words, if forecast is bad, control action is taken before the actual results come through. For example, the graph below shows the feedback and feedforward system for sales:

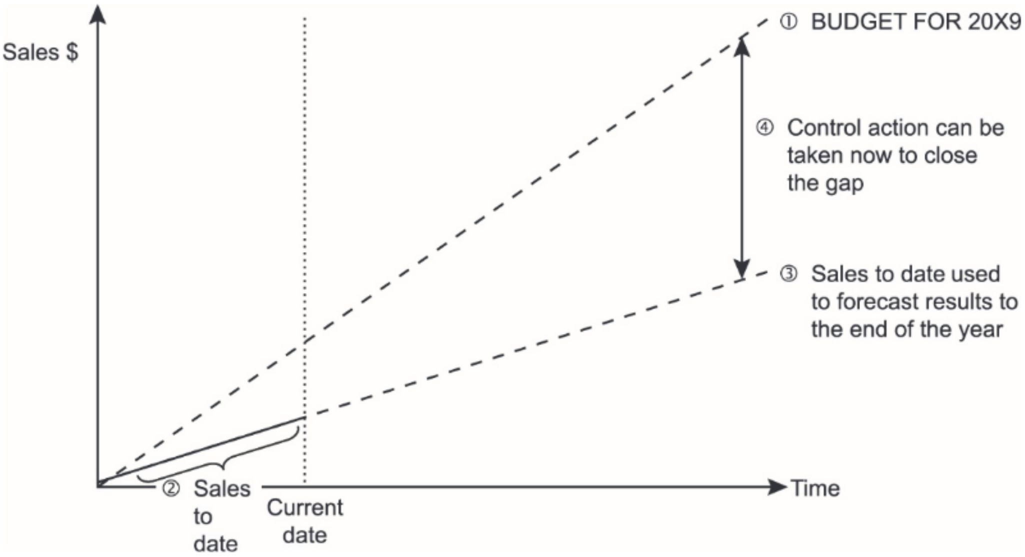


Illustration 2 – Feed-forward control

A sales manager receives monthly control reports about sales values. The budgeted sales for the year to 31 December are $600,000 in total. At the end of April the manager might receive the following **feedback control** report.

Sales report for April

	Month			**Cumulative**		
	Budget	**Actual**	**Variance**	**Budget**	**Actual**	**Variance**
Product	$000	$000	$000	$000	$000	$000
P1	35	38	3 (F)	90	94	4 (F)
P2	20	14	6 (A)	50	39	11 (A)
P3	25	23	2 (A)	50	45	5 (A)
Total	80	75	5 (A)	190	178	12 (A)

Alternatively, the sales manager might be presented with a **feed-forward control** report, as follows:

Sales report, April

	Budget	**Latest forecast for the year**	**Expected Variance**
Product	$000	$000	$000
P1	240	250	10 (F)
P2	150	120	30 (A)
P3	210	194	16 (A)
Total	600	564	36 (A)

The use of a feed-forward control system means that corrective action can be taken to avoid expected adverse variances.

Test your understanding 11

Explain why feed-forward control may be particularly appropriate for the capital expenditure budget.

10 Selecting a suitable budgetary system

As seen, there are many approaches to budgeting and an organisation will wish to select a system which is most appropriate.

Factors, which will determine suitability include:

- type and size of organisation
- type of industry
- type of product and product range
- culture of the organisation.

Illustration 3 – Selecting a suitable budgetary system

PA hospital operates in a relatively stable financial environment, has a very high proportion of fixed costs and a diverse range of activities. Factors to consider when selecting a suitable budgetary system may be:

- An incremental approach may be suitable for all routine activities. New ventures may use a zero-based approach.
- The fixed costs may need close control and therefore some form of ABB may be appropriate.
- The culture of the organisation may dictate whether a participative or imposed budgeting style is more effective. If there are managers who are trained in budgeting and costs are mainly controllable then it may be preferable to adopt a participative approach to empower and motivate staff. If costs are mainly uncontrollable it may be preferable to use a centrally controlled, imposed budget.

Test your understanding 12

Select and justify a suitable budgeting system for a company operating in the mobile phone market.

Information for budgeting

Budgeting requires a great deal of information that can be drawn from many sources.

The main sources of information for budgeting purposes are:

- previous year's actual results.
- other internal sources which may include manager's knowledge concerning the state of repair of non-current assets, training needs of staff, long-term requirements of individual customers, etc.
- estimates of costs of new products using methods such as work study techniques and technical estimates.

- statistical techniques may help to forecast sales.
- models, such as the EOQ model, may be used to forecast optimal inventory levels.
- external sources of information may include suppliers' price lists, estimates of inflation and exchange rate movements, strategic analysis of the economic environment.

Change factors impacting budgeting

The PESTEL model met in BT is useful for identifying change factors:

Political change

A change in government policy, for example fiscal policy, may affect the demand for an organisation's products, and/or the costs incurred in providing them. Any such changes will affect both short-term and long-term planning. This is one reason why planning is a continuous process.

Social change

Changes in social responsibilities and people's attitude towards them affect every organisation. In recent years there has been much more concern about social responsibilities, some of which are now recognised by law. All of these factors may impinge on the plans of the organisation.

Economic change

When there is a change in the economic climate from boom through to recession, the demands upon people's income become more focused. Money tends to be spent on necessary goods with little left for 'luxury goods' and savings. The lack of savings deters investment, with the result that plans have to be modified if they are to be realistic targets. Economic factors could be local, national or international and include global factors such as the banking crisis and its ongoing impact on world economies.

Technological change

When plans are made, they are based upon the use of certain methods and equipment. As technology advances, the older methods are proven to be inefficient, with the result that decisions are taken to update the operation. As a consequence, the aspects of the budgets and plans which related to the old method are no longer relevant. Revised plans must now be drawn up on the basis of the new technology.

Legal change

When plans are made they are based on the current legal framework and known changes to this are also factored in over time. However, changes to the legal framework can cause information that is used when pulling budgets together to become redundant. An example of this might be the government introducing legislation that bans fast food from being advertised during the intervals between children's TV programmes.

Other factors

Note that while a PESTEL analysis can be very useful to identify drivers of change in the industry, it does not automatically detect all factors that cause uncertainty, such as

- Competitive factors, such as the activities of rivals
- Stakeholder factors, such as increased pressure from trade unions to initiate change.

Test your understanding 13

Describe the sources of information required for a company's cash budget.

Changing a budgetary system

A change in the budgetary system could bring about improved planning, control and decision making.

However, before a change is made the following issues should be considered:

- Are suitably trained staff available to implement the change successfully?
- Will changing the system take up management time which should be used to focus on strategy?
- All staff involved in the budgetary process will need to be trained in the new system and understand the procedure to be followed in changing to the new approach. A lack of participation and understanding builds resistance to change.
- All costs of the systems change, e.g. new system costs, training costs, should be evaluated against the perceived benefits. Benefits may be difficult to quantify and therefore a rigorous investment appraisal of the project may be difficult to prepare.

Test your understanding 14

A large holiday complex currently uses incremental budgeting but is concerned about its very high proportion of overhead costs and is considering changing to an activity based budgeting system. Demand follows a fairly predictable seasonal pattern.

Discuss the issues that should be considered before changing to a new budgetary system.

Dealing with uncertainty in budgeting

Budgets are open to uncertainty. For example, non-controllable factors such as a recession or a change in prices charged by suppliers will contribute to uncertainty in the budget setting process.

Uncertainty arises largely because of changes in the external environment, over which a company will have little control. Reasons include:

(1) Social or political unrest could affect productivity (e.g. through industrial action), as could natural disasters like earthquakes and storms.

(2) Machines may break down unexpectedly, and the business may fail to meet production schedules.

(3) Customers may decide to buy more or less goods or services than originally forecast. For example, if a major customer goes into liquidation, this has a huge effect on a company and could also cause them to go into liquidation.

(4) The workforce may not perform as well as expected because of a lack of motivation, illness, etc. On the other hand, they may perform better than thought.

(5) Competitors may strengthen or emerge, and take some business away from a company. On the other hand, a competitor's position may weaken, leading to increased business.

(6) Technological advances may take place which lead a company's products or services to become out-dated and therefore less desirable.

(7) Materials may increase in price because of global changes in commodity prices.

(8) Inflation, as well as movement in interest rates, can cause the price of all inputs to increase or decrease.

There are several **techniques** available to help deal with uncertainty. These have been discussed before and include:

- Flexible budgets: these are budgets which, by recognising different cost behaviour patterns, are designed to change as the volume of activity changes. Flexible budgets are prepared under marginal costing principles, and so mixed costs are split into their fixed and variable components. This is useful at the control stage : it is necessary to compare actual results to the actual level of activity achieved against the results that should have been expected at this level of activity – which are shown by the flexible budget (more on next chapter).
- Rolling budgets: the budget is updated regularly and, as a result, uncertainty is reduced.
- Sensitivity analysis: variables can be changed one at a time and a large number of budgets produced. For example, what would happen if the actual sales volume was only 75% of the budgeted amount?
- Simulation: similar to sensitivity analysis but it is possible to change more than one variable at a time.

Test your understanding 15 – Flexing Budgets

Aoife Co manufactures smartphones and has developed a new handset, the 'H' The maximum production capacity of Aoife Co is 150,000 units of the new handset. The company's management accountant is currently preparing an annual flexible budget and has collected the following information so far for the 'H'.

Production units of 'H'	**100,000 units**	**120,000 units**	**150,000 units**
Material costs	$700,000	$840,000	$1,050,000
Labour costs	$750,000	$900,000	$1,125,000
Incremental fixed costs	$60,000	$60,000	$60,000

In addition to the above costs, the management accountant estimates that for each increment of 15,000 units produced, one supervisor will need to be employed. A supervisor's annual salary is $42,000.

(a) Assuming the budgeted figures are correct, what would the flexed total production cost be if production is 90% of maximum capacity?

(b) The management accountant has said that the factory's smartphone quality control system carries a cost that was not included in the flexible budget, but should be. They estimate that every 1,000 smartphones will take 5 hours to control; every quality control hour has a variable cost of $120 and fixed quality control costs amount to $250,000. What is the estimated quality cost if production of the smartphones is 90% of maximum capacity?

(c) Which TWO of the following statements relating to the preparation of a flexible budget for the 'H' are true?

(1) The budget will encourage all activities and their value to the organisation to be reviewed and assessed.

(2) The flexible budget will give managers more opportunity to include budgetary slack than a fixed budget.

(3) The budget could be time-consuming to produce as splitting out semi-variable costs may not be straightforward.

(4) The range of output over which assumptions about how costs will behave could be difficult to determine.

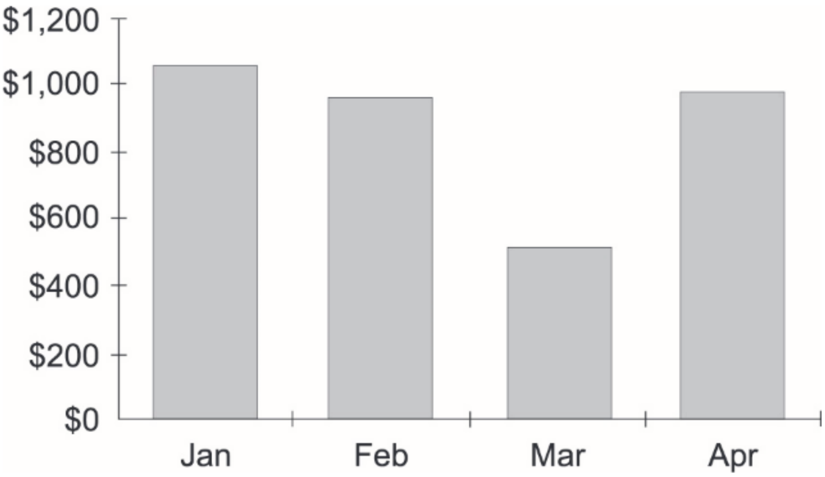
Spreadsheets

A spreadsheet is a computer package which stores data in a matrix format where the intersection of each row and column is referred to as a cell. They are commonly used to assist in the budgeting process.

Advantages of spreadsheets

- Large enough to include a large volume of information.
- Formulae and look up tables can be used so that if any figure is amended, all the figures will be immediately recalculated. This is very useful for carrying out sensitivity analysis.
- The results can be printed out or distributed to other users electronically quickly and easily.
- Most programs can also represent the results graphically e.g. balances can be shown in a bar chart.

Closing cash balances



Disadvantages of spreadsheets:

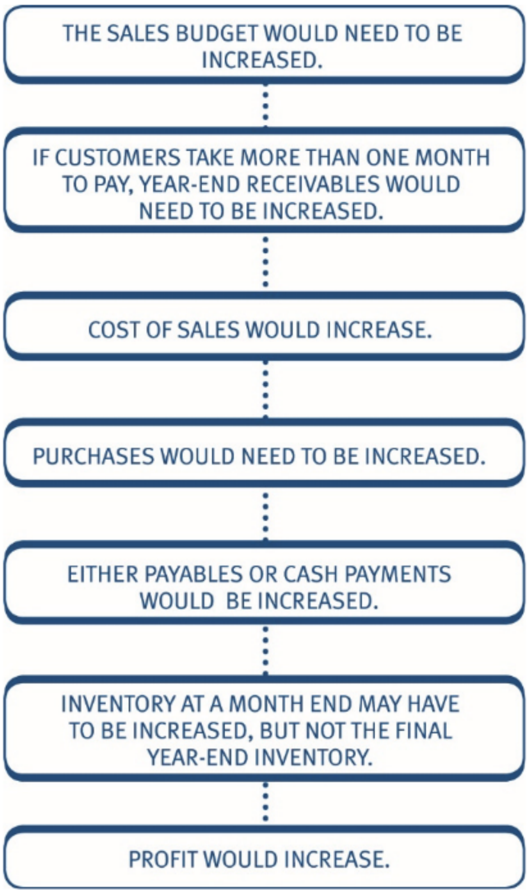
- Spreadsheets for a particular budgeting application will take time to develop. The benefit of the spreadsheet must be greater than the cost of developing and maintaining it.
- Data can be accidentally changed (or deleted) without the user being aware of this occurring.
- Errors in design, particularly in the use of formulae, can produce invalid output. Due to the complexity of the model, these design errors may be difficult to locate.
- Data used will be subject to a high degree of uncertainty. This may be forgotten and the data used to produce, what is considered to be, an 'accurate' report.

- Security issues, such as the risk unauthorised access (e.g. hacking) or a loss of data (e.g. due to fire or theft).
- Version control issues can arise.
- Educating staff to use spreadsheets/models and which areas/cells to use as inputs can be time consuming.

Illustration 4 – Using spreadsheets in budgeting

When producing a master budget manually the major problem is ensuring that any initial entry in the budget or any adjustment to a budget item is dealt with in every budget that is relevant – in effect, budgets need to comply with normal double entry principles to be consistent.

Suppose, for instance, that sales in the last month were expected to rise by $10,000, what adjustments would be necessary?



THE SALES BUDGET WOULD NEED TO BE INCREASED.

IF CUSTOMERS TAKE MORE THAN ONE MONTH TO PAY, YEAR-END RECEIVABLES WOULD NEED TO BE INCREASED.

COST OF SALES WOULD INCREASE.

PURCHASES WOULD NEED TO BE INCREASED.

EITHER PAYABLES OR CASH PAYMENTS WOULD BE INCREASED.

INVENTORY AT A MONTH END MAY HAVE TO BE INCREASED, BUT NOT THE FINAL YEAR-END INVENTORY.

PROFIT WOULD INCREASE.

Using spreadsheets all of the above adjustments could be processed automatically if the relevant formulae were set up properly. Receivables, cost of sales, purchases, payables, cash, inventory and profit could change instantly on adjusting sales of month 12.

11 Beyond Budgeting

Examiner's article: visit the ACCA website, www.accaglobal.com, to review the examiner's article written on this topic.
https://www.accaglobal.com/ca/en/student/exam-support-resources/fundamentals-exams-study-resources/f5/technical-articles/budgeting5.html

The whole concept of budgeting turns around the idea that the operation of an organisation can be meaningfully planned for in some detail over an extended period into the future. Further, that this plan can be used to guide, control and co-ordinate the activities of numerous departments and individuals within the organisation.

The modern economic environment is associated with a **rapidly changing environment, flexible manufacturing, short product life-cycles and products/services which are highly customised**. The 'lean business' and the 'virtual business' are responses to this. Such businesses own limited assets of the traditional kind but assemble resources as and when needed to meet customer demand. The keys to their operation are flexibility and speed of response. They are able to move quickly to exploit opportunities as they arise and do not operate according to elaborate business plans.

"In an age of discontinuous change, unpredictable competition, and fickle customers, few companies can plan ahead with any confidence – yet most organisations remain locked into a 'plan-make-and-sell' business model that involves a protracted annual budgeting process based on negotiated targets and that assumes that customers will buy what the company decides to make. Such assumptions are no longer valid in an age when customers can switch loyalties at the click of a mouse."

J Hope and R Fraser. Beyond Budgeting (Strategic Finance 10/2000)

'Beyond Budgeting' (BB) is the generic name given to a body of practices intended to replace budgeting as a management model. The core concept is the need to move from a business model based on centralised organisational hierarchies to one based on devolved networks.

Beyond Budgeting is defined in CIMA's Official Terminology as 'the idea that companies need to move beyond budgeting because of the inherent flaws in budgeting especially when used to set incentive contracts. It is argued that a range of techniques, such as rolling forecasts and market-related targets, can take the place of traditional budgets.'

12 Beyond Budgeting – 6 principles

A beyond budgeting implementation should incorporate the following six main principles:

(1) An organisation structure with **clear principles and boundaries**; a manager should have no doubts over what he/she is responsible for and what he/she has authority over; the concept of the internal market for business units may be relevant here.

(2) Managers should be given goals and targets which are based on **relative success** and linked to shareholder value; such targets may be based on key performance indicators and benchmarks following the balanced scorecard principle.

(3) Managers should be given a **high degree of freedom** to make decisions; this freedom is consistent with the total quality management and business process reengineering concepts; a beyond budgeting organisation chart should be 'flat'.

(4) Responsibility for decisions that generate value should be placed with '**front line teams'**; this is consistent with modern process improvements such as Total Quality Management (TQM) and Business Process Redesign (BPR) concepts which take a clean sheet approach to process redesign and aim for continuous improvement (often driven by the end user).

(5) Front line teams should be made responsible for **relationships** with customers, associate businesses and suppliers; direct communication between all the parties involved should be facilitated; this is consistent with the SCM concept.

(6) Information support systems should be transparent and ethical; an activity based accounting system which reports on the activities for which managers and teams are responsible is likely to be of use in this regard.

"Beyond Budgeting (BB) is essentially an approach that places modern management practices within a cultural framework.

The process of management is not about administering fixed budgets, it is about the dynamic allocation of resources"

Lord Browne, former CEO of BP

13 Benefits of Beyond Budgeting

All the cases studied are different, but the following general benefits for beyond budgeting are claimed:

(1) **Faster response time** – operating within a flexible organisational network and with strategy as an 'adaptive process' allows managers to respond quickly to customer requests.

(2) **Better innovation** – managers working within an environment wherein performance is judged on the basis of team and business unit results encourages the adoption of new innovations. Relations with customers and suppliers through supply chain management may facilitate the adoption of new working methods and technologies.

(3) **Lower costs** – in the context of beyond budgeting managers are more likely to perceive costs as scarce resources which have to be used effectively than as a budget 'entitlement' that has to be used. Beyond budgeting is also likely to promote an awareness of the purposes for which costs are being incurred and thereby the potential for reductions.

(4) **Improved customer and supplier loyalty** – the leading role of front line teams in dealing with customers and suppliers is likely to deepen the relevant relationships.

As with many innovations in management practice, beyond budgeting was a creature of its time. It appeared in the mid-1990s at a time when globalisation and advances in IT were tending to speed up the business environment. In particular, customers had greater choice and expected faster service. The key competitive constraint in most business situations is no longer land, labour or capital. For example, if labour is locally scarce then work can be outsourced to India or manufacturing can be relocated to China. In many practical business situations the key competitive factor is likely to be intellectual and knowledge based in character.

The beyond budgeting model appeared as a set of information-age best practices which was attuned to the new situation. Beyond budgeting is intended to be an exercise in mobilising competent managers, skilled workers and loyal customers. However, traditional budgeting still has its defenders. Such defenders claim that while budgeting may be associated with a 'command and control' management style, it is the management style that is the problem and not budgeting.

e.g

Svenska Handelsbanken

Researchers have explored the history of Beyond Budgeting implementations to determine whether or not these have delivered improved results. The Beyond Budgeting Institute has reported several case studies, the best known of which is that of **Svenska Handelsbanken**.

This Swedish bank abandoned budgeting in 1972 and switched to delegation model (involving 600 autonomous work units) that avoids formal planning and target setting. Branch managers run their own businesses and are able to decide how many staff they need, where they obtain support services from and what products they market to which customers. Branch performance is assessed using measures such as customer profitability, customer retention and work productivity.

The Svenska Handelsbanken model might indicate a higher level of corporate risk with all that would imply for cost of money and market capitalisation. However, it is claimed that the model favours flexibility. In the absence of a fixed plan, products and projects are designed to allow easy modification and exit routes. This view suggests that the model invites a different approach to risk management rather than the acceptance of higher risk.

14 Ethics and sustainability in budgeting

As we discussed in chapter 4, it is an important part of a management accountant’s role to focus on longer term sustainability as part of the responsibilities of a finance professional. Combined with professional ethics, this therefore requires management accountants to ensure that budgets are not encouraging behaviour from budget holders that threatens these principles, and instead, budgets should take into account long-term sustainability rather than purely target short-term profit.

This can be partially achieved through processes such as **environmental management accounting (EMA)** as mentioned in chapter 4, as this allows accountants to build in environmental costs into budgets.

We also looked at **triple bottom line** accounting in chapter 4, which can be useful in setting budget targets for managers, under the three headings of people, planet, and profit.

An alternative approach to budgeting to build in the additional costs related to these factors is full cost accounting:

Full cost accounting

Full cost accounting (FCA) attempts to include all the costs of an action, decision or manufacture of a product into a costing system. Most budgets and financial accounts are based on actual costs incurred. FCA includes the additional (and in many situations non-financial costs) of those actions. The aim is to internalise all costs, including those which are incurred outside of the company.

- Full cost accounting means calculating the total cost of company activities, including environmental, economic and social costs.
- It attempts to include all the costs of an action, decision or manufacture of a product into a costing system, and as such will include many non-financial costs of certain actions.
- The aim of full cost accounting is to internalise all costs, even those which are incurred outside of the company.

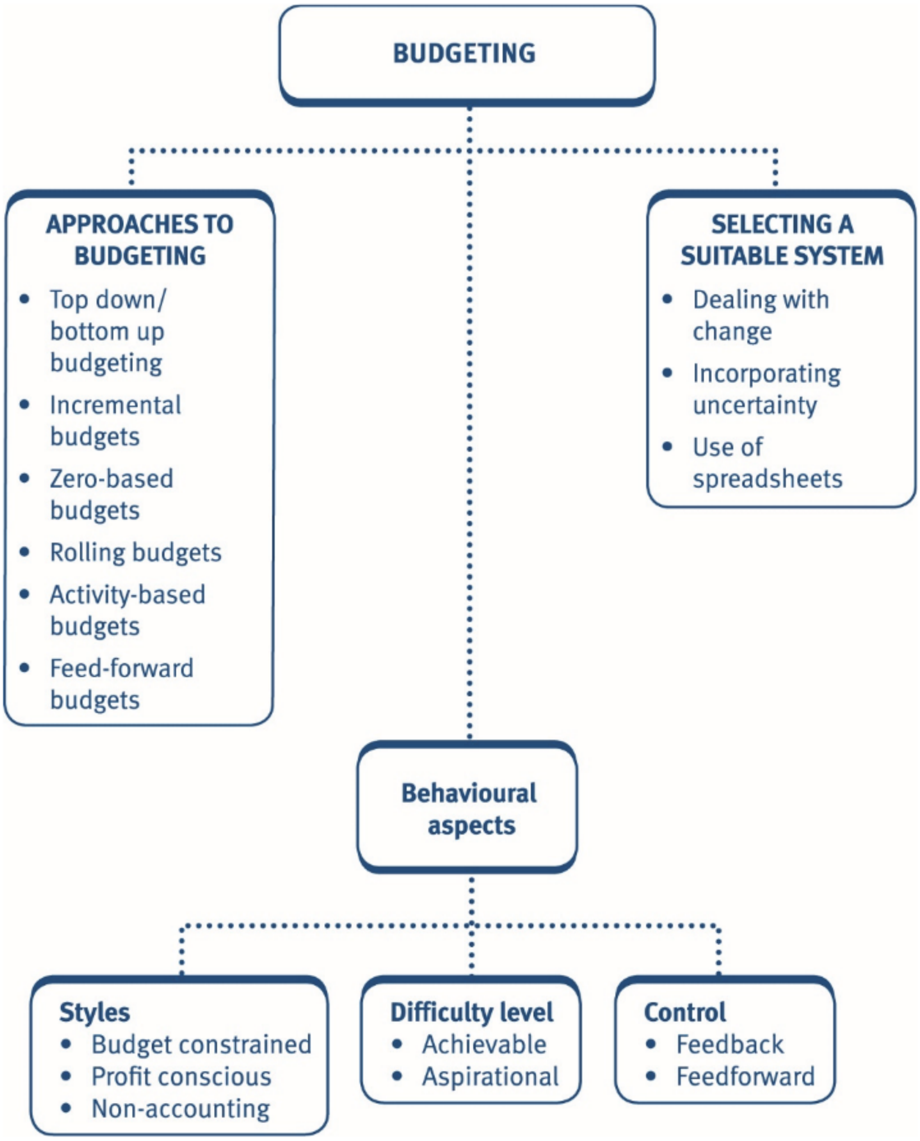
Taking car manufacture as an example:

- An initial outlay on a factory will be included within one year's budget. However, that factory will incur costs in every year it is used and therefore those costs must be shown as being incurred over the life of the factory.
- The location of the factory may incur costs even though no cash outlay is involved. For example, the time lost from traffic queues as workers attempt to reach the factory, or the additional cost of pollution from cars in those queues are costs, even though the company has no financial outlay for them.

- The cars being manufactured will have a finite life, however the company has no obligation to dispose of the used product at the end of that life. FCA would include the disposal cost and associated environmental damage. Some car manufacturers have recognised this cost and now advertise their cars as being recyclable, even if the company does not actually carry out that recycling (yet).

FCA is therefore the normal 'costs' in terms of running a company with the additional costs to recognise the external costs.

15 Chapter summary



Test your understanding answers

Test your understanding 1 – Evaluation of managers

The key point here is that the answer depends on who awarded the pay increase.

If this was the production manager's decision, then the cost would be controllable. Depending on the culture of the firm, the manager would then be under pressure to explain why they departed from the budget in this instance.

If awarded by, say, the board of directors, then the cost increase was not controllable by the manager and should not feature in their appraisal.

Note: The concept of controllability is important for the exam.

Test your understanding 2

The manager may try to:

- delay discretionary short-term expenditure, e.g. maintenance, at the expense of long-term performance to improve results.
- manipulate results to make sure the relevant targets are achieved.
- incorporate budgetary slack into the targets to make them easier to achieve.

The process can be improved by measuring performance against a variety of targets, including non-financial targets, and linking performance to long-term objectives.

Test your understanding 3

Sales are expected to be $550,000 × 110% × 103% = $623,150. The manager may accept this as a fair target for performance appraisal, planning and control purposes. To encourage the manager to improve further an aspirations target incorporating a further improvement, say to $650,000, could be used and linked to the reward system.

Test your understanding 4

(1) Operational managers may not have the knowledge and experience to set a budget. For example, in a small business only the owner may be involved in all aspects of the business and may therefore set the budget.

(2) In times of crisis there may be insufficient time to set a participative budget and targets may have to be imposed to ensure survival.

(3) Participation has to be genuine for it to result in improved motivation. Pseudo-participation, where senior managers seek the opinions of the ultimate budget holders but do not act on these views, may lead to demotivation.

Test your understanding 5

	Total variable cost	**Variable cost per unit**
20X4:		
Product A	$672,000 × 75% × 60% = $302,400	$302,000 ÷ 640 units = $472.50
Product C	$672,000 × 75% × 40% = $201,600	$201,600 ÷ 350 units = $576
20X5:		
Product A	$472.50 × 1.04 × expected output 750 units = $368,550	
Product C	$576 × 1.04 × expected output 340 units = $203,674	

Test your understanding 6

Stage 1: Managers should specify the activities that can be evaluated

The managers/researchers responsible for each project should decide which projects they wish to undertake in the forthcoming period. These projects will be a mixture of continued projects and new projects.

Stage 2: Each activity is described in a decision package

For the projects which have already been started and which the managers want to continue in the next period, we should ignore any cash flows already incurred (they are sunk costs), and we should only look at future costs and benefits. Similarly, for the new projects we should only look at the future costs and benefits.

Stage 3: Each decision package is evaluated and ranked

Different ways of achieving the same research goals should also be investigated and the projects should only go ahead if the benefit exceeds the cost.

Stage 4: Resources are allocated to the various packages

Once all the potential projects have been evaluated if there are insufficient funds to undertake all the worthwhile projects, then the funds should be allocated to the best projects on the basis of a cost-benefit analysis.

ZBB is usually of a highly subjective nature. (The costs are often reasonably certain, but usually a lot of uncertainty is attached to the estimated benefits.) This can be shown by the example of a research division where the researchers may have their own pet projects, which they are unable to view in an objective light.

Test your understanding 7

The revised budget should incorporate 3% growth starting from the actual sales figure of Quarter 1 and should include a figure for Quarter 1 of the following year.

	Quarter 2	Quarter 3	Quarter 4	Quarter 1	Total
	$	$	$	$	$
Sales	127,154	130,969	134,898	138,945	531,966

Test your understanding 8

The total annual material purchases will be the sum of the next four quarters i.e. the remaining quarters of the current year (Y1 quarters 2, 3 and 4) plus the first quarter of the following year (Y2 quarter 1). The budgets for these quarters will have been updated based on the actual material purchases from quarter 1 ($210,000) and the predicted cost increase of 1%.

	Year 1 Q1 Actual	Year 1 Q2 Budget	Year 1 Q3 Budget	Year 1 Q4 Budget	Year 2 Q1 Budget
	$	$	$	$	$
Materials purchases (increasing at 1% per quarter)	210,000	212,100	214,221	216,363	218,527

The total annual material purchases figure in the updated rolling budget would therefore be $212,100 + $214,221 + $216,363 + $218,527 = **$861,211**

Test your understanding 9 – Preparing an ABB

Step 1	Identify cost pools and cost drivers.
Step 2	Calculate a budgeted cost driver rate based on budgeted cost and budgeted activity.
Step 3	Produce a budget for each department or product by multiplying the budgeted cost driver rate by the expected usage.

Test your understanding 10

D is the correct answer.

Situation A would be best suited by implementing Zero Base Budgeting. Situation B does not require ABB since it has relatively low overheads. Situation C would be suitable for incremental budgeting. ABB will certainly not be quicker.

Test your understanding 11

Capital expenditure is often long-term in nature. It is more useful to compare actual costs to forecast completion costs so that action can be taken when a project is in progress rather than waiting for completion.

Test your understanding 12

The mobile phone market is intensely competitive so a company will need sophisticated systems to gather information about the market and competitors. The market is also fast changing so a rolling budget approach may be suitable to keep budget targets up to date. It will be very important to incorporate the latest information into budgets and a participative approach will be important as production managers and sales managers may have local knowledge which would improve the budgeting process.

Test your understanding 13

Internal information will be required from the:

- sales department relating to volume and estimated collection periods
- the production manager will estimate material, labour and overhead usage
- the purchasing manager will estimate material prices and payment terms
- human resources will forecast pay rates, bonus payments and overtime requirements
- the finance office may forecast payments of interest, dividends and general office costs.

External information may be required relating to forecast interest rates, tax rates, payment terms for tax, exchange rates, inflation, etc.

Test your understanding 14

An analysis of overheads should be carried out to determine the proportion that have identifiable cost drivers which differ from the normal volume related cost drivers which may be used when carrying out incremental budgeting. If a substantial volume of overhead is non-volume related then implementing ABB may lead to more accurate planning and control.

Issues, which should then be considered include:

- the development or purchase of a suitable computer system to support an ABB process
- training of staff to operate and interpret the information produced
- development of an implementation plan and whether this should run in tandem with the existing process for a trial period.

Test your understanding 15 – Flexing Budgets

(a) 90% of capacity = 90% × 150,000 = 135,000 units

Stepped supervisor costs = 135,000/15,000 = 9 steps

Material cost = 135,000 × $7 per unit = $945,000

Labour cost = 135,000 × $7.50 = $1,012,500 Fixed costs = $60,000

Stepped costs = 9 steps × $42,000 per step = $378,000

Total flexed production cost = $2,395,500

(b) 90% of capacity = 90% × 150,000 = 135,000 units

Fixed quality control costs $250,000

(135,000 smartphones/1,000 units) = 135 × 5 hours × $120 = $81,000

Total = $331,000.

(c) Statements 3 and 4 are correct.

It is a zero-based budget, not a flexible budget, which assesses all activities for their value to the organisation, so Statement 1 is incorrect.

A flexible budget will not be better or worse than a fixed budget in terms of including budgetary slack, so Statement 2 is incorrect.

Flexible budgeting can be time-consuming to produce as splitting out semi-variable costs could be problematic, so Statement 3 is correct.

Estimating how costs behave over different levels of activity can be difficult to predict, so Statement 4 is correct.

Chapter

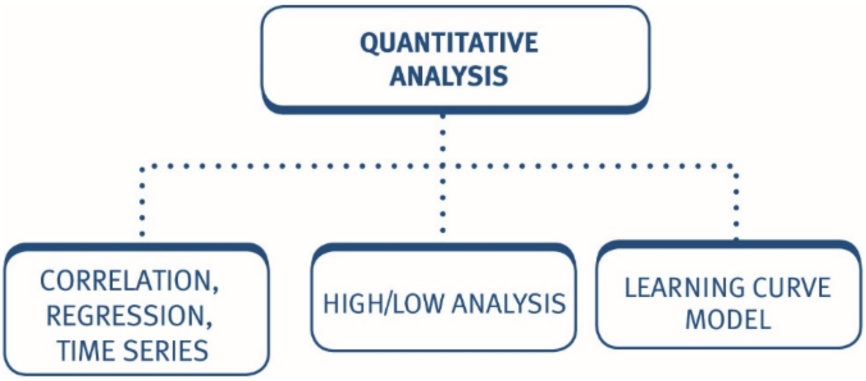
11

Quantitative techniques

Chapter learning objectives

Upon completion of this chapter you will be able to:

- analyse fixed and variable cost elements from total cost data using high/low method.
- explain and apply analysis techniques including correlation, regression and time series.
- estimate the learning rate and learning effect.
- apply the learning curve model to a budgetary problem, including calculations on steady states.
- discuss the benefits and limitations of correlation, regression and time series techniques, and, also the reservations with the learning curve model.



1 High/low analysis

A method of analysing a semi-variable cost into its fixed and variable elements based on an analysis of historical information about costs at different activity levels.

The fixed and variable costs can then be used to forecast the total cost at any level of activity.

The approach is as follows:

Step 1

Select the highest and lowest **activity** levels, and their costs.

Step 2

Find the variable cost/unit.

$$\text{Variable cost/unit} = \frac{\text{(Cost at high level of activity – Cost at low level activity)}}{\text{(High level activity – Low level activity)}}$$

Step 3

Find the fixed cost, using either the high or low activity level.

Fixed cost = Total cost at activity level – Total variable cost

Step 4

Use the variable and fixed cost to forecast the total cost for a specified level of activity.

Advantages of high/low analysis

- The high-low method is simple to calculate.
- It is easy to understand and easy to use.

Disadvantages of high/low analysis

- It assumes that activity is the only factor affecting costs.
- It assumes that historical costs reliably predict future costs.
- It uses only two values, the highest and the lowest, so the results may be distorted due to random variations in these values.

Test your understanding 1 – High-low analysis

Cost data for the six months to 31 December 20X8 is as follows:

Month	Units	Inspection costs $
July	340	2,240
August	300	2,160
September	380	2,320
October	420	2,400
November	400	2,360
December	360	2,280

Required:

Use high/low analysis to find the variable cost per unit, and the total fixed cost. Forecast the total cost when 500 units are produced.

Additional example on high/low

Output (units)	Total cost ($)
200	7,000
300	8,000
400	9,000

(a) Find the variable cost per unit.

(b) Find the total fixed cost.

(c) Estimate the total cost if output is 350 units.

(d) Estimate the total cost if output is 600 units.

Solution

(a) Variable cost per unit = ($9,000 – $7,000) ÷ (400 – 200)

= $10 per unit

(b) Using high activity level:

Total cost	=		$9,000
Total variable cost	=	400 × $10	$4,000
Therefore Fixed cost	=		$5,000

(c)	If output is 350 units:			
	Variable cost	=	350 × \$10 =	\$3,500
	Fixed cost	=		\$5,000
	Total cost	=		\$8,500
(d)	If output is 600 units:			
	Variable cost	=	600 × \$10	\$6,000
	Fixed cost	=		\$5,000
	Total cost	=		\$11,000

2 Introduction to learning curves

Examiner's article: visit the ACCA website, www.accaglobal.com, to review the examiner's article written on this topic.
https://www.accaglobal.com/ca/en/student/exam-support-resources/fundamentals-exams-study-resources/f5/technical-articles/the-learning-rate-and-learning-effect.html

It has been observed in some industries that there is a tendency for labour time per unit to reduce in time: as more of the units are produced, workers become more familiar with the task and get quicker.

From the experience of aircraft production during World War II, aircraft manufacturers found the rate of improvement was so regular that it could be reduced to a formula, and the labour hours required could be predicted with a high degree of accuracy from a **learning curve**.

The first time a new operation is performed, both the workers and the operating procedures are untried. As the operation is repeated, the workers become more familiar with the work, labour efficiency increases and the **labour cost per unit declines**.

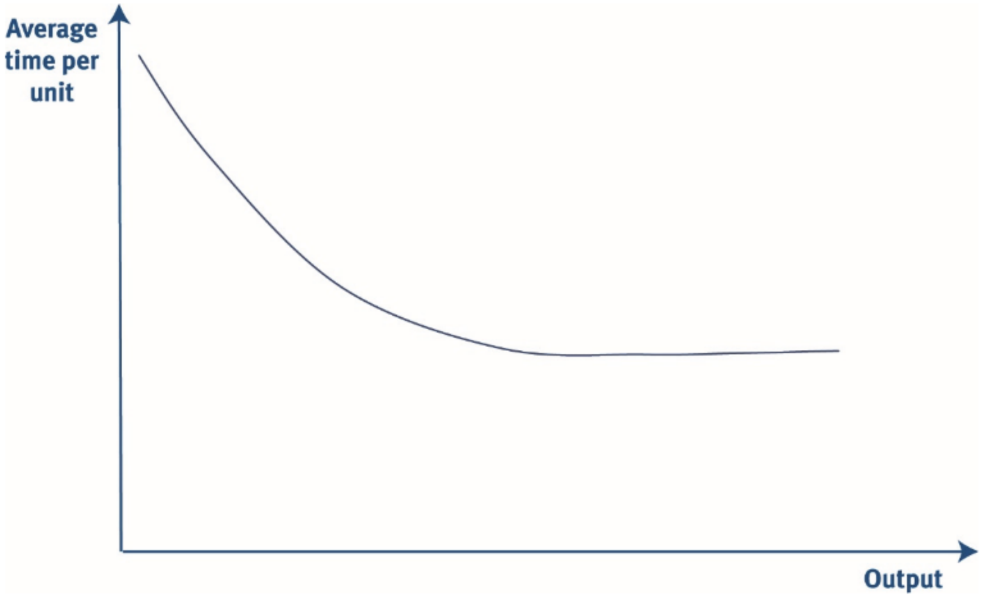
Wright's Law

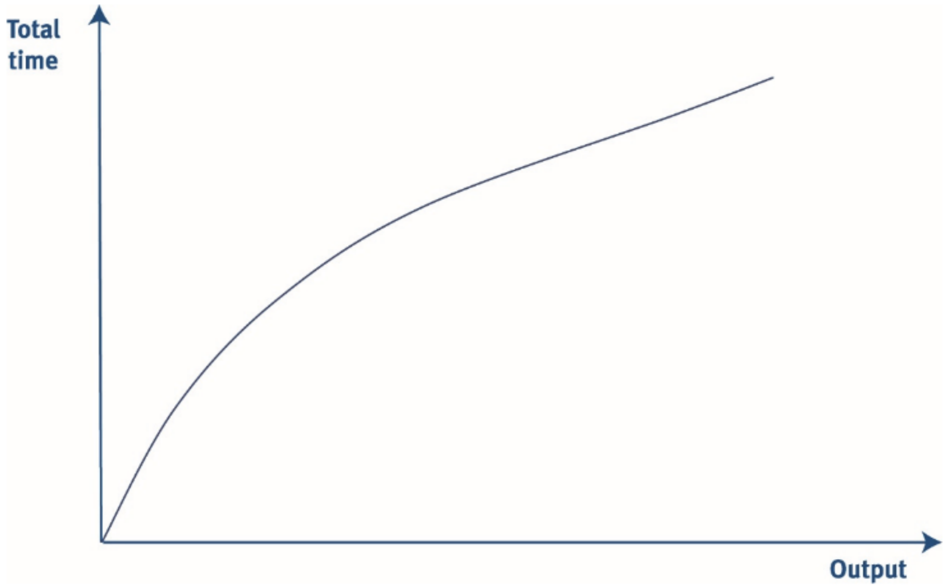
Wright's Law states that as cumulative output doubles, the cumulative average time per unit falls to a fixed percentage (the **'learning rate'**) of the previous average time.

The learning curve is 'The mathematical expression of the commonly observed effect that, as complex and labour-intensive procedures are repeated, unit labour times tend to decrease.'

The learning process starts from the point when the first unit comes off the production line. From then on, each time **cumulative** production is doubled, the **cumulative average time per unit** is a fixed percentage of its previous level.

For example, a 90% learning curve means that each time cumulative output doubles the cumulative average time per unit falls to 90% of its previous value.





3 Limitations of the Learning Curve model

The learning curve model has its limitations. Learning effects are most likely to be seen if:

- **The process is labour intensive.**

  Modern manufacturing environments may be very capital intensive (i.e. machine intensive) and the labour effect cannot apply if machines limit the speed of labour.

- **The product is new.**

  This may be the case in the modern environment as products have short lives and therefore new products will be introduced on a regular basis. The introduction of a new product makes it more probable that there will be a learning effect.

- **The product is complex.**

  The more complex the product the more likely that the learning curve will be significant, and the longer it will take for the learning curve to reach a steady state or 'plateau' (beyond which no more learning can take place).

- **Production is repetitive and there are no breaks in production.**

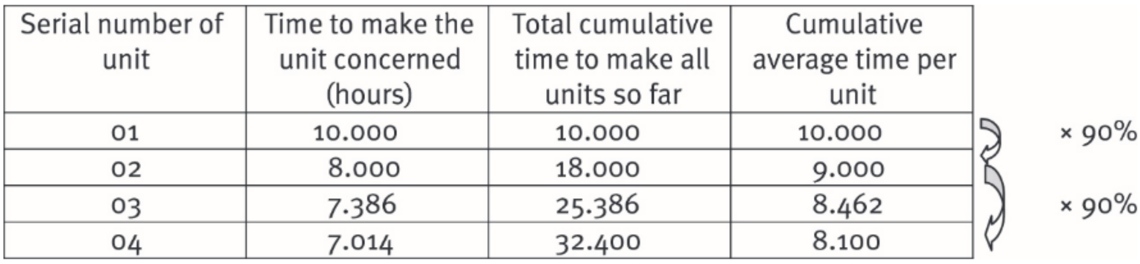
  The learning effect requires that production is repetitive with no major breaks in which the learning effect may be lost. JIT production has moved towards multi-skilled and multi-tasked workers. It is possible that some of the benefits of the learning effect in a single tasking environment may be lost. The production of small batches of possible different products in response to customer demand may also lead to the loss of some of the learning effect.

4 The tabular approach

Consider the following example of the time taken to make the first four units of a new product:

Serial number of units	**Time to make the unit concerned (hours)**
01	10 hours
02	8 hours
03	7.386 hours
04	7.014 hours

While it is clear that we are getting quicker, it is not obvious how the times to make successive units are related. However, a pattern becomes apparent if we look at the cumulative average time per unit instead:



Serial number of unit	Time to make the unit concerned (hours)	Total cumulative time to make all units so far	Cumulative average time per unit
01	10.000	10.000	10.000
02	8.000	18.000	9.000
03	7.386	25.386	8.462
04	7.014	32.400	8.100

In this example, Wright's Law is verified as the cumulative average decreases to 90% of the previous average every time we double the cumulative output, such as from 1 to 2 or from 2 to 4 units. We therefore say that the process demonstrates a **90% learning rate**.

All learning curve calculations use this idea of a cumulative average, so imagine all units having serial numbers so you can see how they fit into the cumulative picture.

For example, how long would it take to make a further 4 units, doubling the cumulative total to 8? The order of calculations is very important:

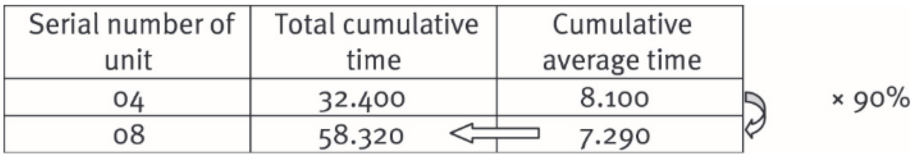
Step 1: Calculate the cumulative average time for the target production. Here, the cumulative average for the first 8 units = 8.100 × 90% = 7.290 hours per unit

Step 2: Calculate the total cumulative time. The total cumulative time for the first 8 units = 7.290 × 8 = 58.320 hours

Step 3: Time to make the next 4 units = the time to make 8 in total – the time to make the first 4

Time to make next 4 units = 58.320 – 32.400 = 25.920 hours.

Or, shown as a table:



Serial number of unit	Total cumulative time	Cumulative average time
04	32.400	8.100
08	58.320	7.290

Test your understanding 2 – Learning Curve table

A new product will take 100 hours for the first unit. An 80% learning curve applies.

Required:

Complete the table.

Cumulative			Incremental		
Units	**Average time per unit**	**Total time**	**Units**	**Total time**	**Average time per unit**
1					
2					
4					
8					
16					

5 The algebraic approach

The problem with total doubling is that we cannot calculate averages for all levels of production. For example, how would we go about calculating how long the fifth unit should take to make?

The learning curve table in the tabular approach is useful if output keeps doubling, but for intermediate output levels we can obtain the information we need with the following formula:

$$Y = a * x^b$$

Where

- x = cumulative number of units
- Y = cumulative average time per unit to produce x units
- a = time required to produce the first unit of output
- b = index of learning = log r/log 2, where r = the learning rate expressed as a decimal.

Algebraic approach example

Assume that it takes 400 direct labour hours to produce the first unit of a new product and an 85% learning curve applies.

Required:

Calculate the total time to produce the third unit.

Solution

- b = log(0.85)/log 2

  b = –0.0706/0.3010 = –0.234
- The cumulative average time to produce the first two units is

  $y = 400 \times 2^{-0.234} = 340.1$.

  The total time to produce the first two units = 340.1 × 2 = 680.2 hours.
- The cumulative average time to produce the first three units is

  $y = 400 \times 3^{-0.234} = 309.3$.

  The total time to produce the first three units = 309.3 × 3 = 927.9 hours.
- The time to produce the third unit = 927.9 – 680.2 = 247.7 direct labour hours.

Test your understanding 3 – Learning Curve calculations

The first unit of a new product is expected to take 100 hours. An 80% learning curve is known to apply.

Calculate:

(a) the average time per unit for the first 16 units

(b) the average time per unit for the first 25 units

(c) the time it takes to make the 20th unit.

Test your understanding 4 – Cessation of the learning curve effect

The first batch of a new product took 20 hours to produce. The learning rate is 90%.

Required:

If the learning effect ceases after 72 batches (i.e. all subsequent batches take the same time as the 72nd), how long will it take to make 100 batches?

Note: there is an alternative calculation we can use if (and only if) we have a specific number of times the number of units has doubled:

$$\mathbf{Y = a * r^n}$$

Where

- r = the learning rate expressed as a decimal.
- Y = cumulative average time per unit to produce x units
- a = time required to produce the first unit of output
- n = number of times the units have doubled since the first unit was produced.

Test your understanding 5 – Product X

Average unit times for product X have been tabulated as follows

Unit number	**Cumulative average time per unit Y_x**
1	20 minutes
8	12.72 minutes

Required:

What is the learning rate?

Test your understanding 6 – SCW Co

SCW Co has budgeted for a learning rate of 95% on the production of its new product Q, which is still at the development stage.

Actual results were as follows:

- Time to make the first unit of Q = 40 minutes
- Time to make the first 8 units = 233 minutes

Required:

(a) Calculate the actual learning rate, assuming a steady state has not been reached.

(b) Give TWO possible reasons why the rate is different from anticipated.

Test your understanding 7 – Calculate the learning rate

The times taken to produce each of the first four batches of a new product were as follows:

Batch number	Additional time taken
1	100 minutes
2	70 minutes
3	62 minutes
4	57 minutes

Based upon the above data, the rate of learning was closest to

A 70%

B 72.25%

C 82%

D 85%

Test your understanding 8 – Learning Curve statement

'The learning curve is a simple mathematical model but its application to management accounting problems requires careful thought.'

Required:

Having regard to the above statement:

(a) **explain** the 'cumulative average-time' model commonly used to represent learning curve effects.

(b) **explain** the use of learning curve theory in budgeting and budgetary control; explain the difficulties that the management accountant may encounter in such use.

(c) **explain** the circumstances in which the use of the learning curve may be most relevant.

Test your understanding 9 – Swiss watch

A Swiss watch making company wishes to determine the minimum price it should charge a customer for a special order of watches. The customer has requested a quotation for 10 watches (1 batch), but might subsequently place an order for a further 10. Material costs are $30 per watch. It is estimated that the first batch of 10 watches will take 100 hours to manufacture and an 80% learning rate is expected to apply. Labour plus variable overhead costs amount to $3 per hour. Setup costs are $1,000 regardless of the number of watches made.

Required:

(a) What is the minimum price the company should quote for the initial order if there is no guarantee of further orders?

(b) If the company was then to receive the follow-on order, what would the minimum price of this order be?

(c) What would be the minimum price if both orders were placed together?

(d) Having completed the initial orders for a total of 20 watches (price at the minimum levels recommended in (a) and (b)), the company thinks that there would be a ready market for this type of watch if it brought the unit selling price down to $45. At this price, what would be the profit on the first 140 'mass-production' watches (i.e. after the first 20 watches) assuming that marketing costs totalled $250?

Applications of the learning effect

- Pricing decisions: prices will be set too high if based on the costs of making the first few units.
- Work scheduling: less labour per unit will be required as more units are made. This may have management implications, e.g. workers may be laid off.
- Product viability: the viability of a product may change if a learning effect exists. For example, a product that will make a loss based on the labour cost for the time taken on production of the early units, may become profitable once the learning effect has reduced the labour cost sufficiently, and so the product will become viable once we are producing higher volumes.
- Standard setting: if a product enjoys a learning effect but this effect is ignored, then the standard cost will be too high. The presence of a learning effect can also make standard setting difficult. Ignoring a learning effect could result in a need to calculate planning and operating variances.
- Budgeting: the presence of a learning effect should be taken into account when setting budgets. For example, the labour budget may be reduced by a learning effect but working capital may be required sooner than expected.

6 Learning curve and steady state

The learning effect will only apply for a certain range of production. (For example, in TYU4, the learning effect ceases after 72 batches).

For example, machine efficiency may restrict further improvements or there may be go-slow arrangements in place.

Once the steady state is reached the direct labour hours will not reduce any further and this will become the basis on which the budget is produced.

The experience curve

It has been stressed that the learning curve was derived from observations of the reductions in direct labour time taken to complete successive repetitive but complex assembly tasks. However, learning rates have frequently been determined by fitting curves to total cost per unit data. For example, DePuy (1993) used this method to ascertain for the US government the learning rate achieved by defence contractors. The purpose in gathering this data was to help in price negotiations with the contractors.

The slope of the learning curves derived ranged from 0.718 to 1.021, with a mean of 0.858. These data suggest that defence contractors typically enjoy a reduction of 14 per cent of average unit cost on each doubling of output. The strict application of the learning curve phenomenon is seen in the area of direct labour, and it is arguable that, in using unit cost data, the result outlined above actually reflects the so-called ‘experience curve; rather than the learning curve as strictly defined. The ‘experience curve’ extends the learning curve approach to areas other than direct labour. Rather than relating indirectly to cost via time, an experience curve relates directly to cost, and it is a function which shows how total cost per unit declines as output increases.

Total cost in experience curves includes all overhead types – production, marketing and distribution – and thus cost reduction arising from factors such as factory size, production technology, substitution of materials and design modifications are reflected in an experience curve.

Experience curves, like learning curves, can be regarded as statements of what will happen in practice. This could be considered to be a western approach. An alternative approach, adopted by the Japanese, is that these curves should be taken as expressions of what is desirable, and hence what should be striven for.

The improvement-oriented Japanese typically aim actively to foster a 67 per cent learning curve, as against the 80 per cent curve more usually found in the west.

Test your understanding 10 – Bike Racers Co

Bike Racers Co has designed a radically new concept in racing bikes, with the intention of selling them to professional racing teams. The estimated cost and selling price of the first bike to be manufactured and assembled is as follows:

Materials	$1,000
Assembly labour (50 hours at $10 per hour)	$500
Fixed overheads (200% of assembly labour)	$1,000
Profit (20% of total cost)	$500
Selling price	**$3,000**

Bike Racers Co plans to sell all bikes at total cost plus 20%, and the material cost per bike will remain constant, irrespective of the number sold. Bike Racers Co's management expects the assembly time to gradually improve with experience, and has estimated a 80% learning curve.

(1) Mr Wiggo, a racing team manager, approached Bike Racers Co in January 20X5 and committed to buy the first bike, as well as the second bike produced.

What price should be charged by Bike Racers Co for the second bike produced?

A $2,280

B $2,400

C $2,640

D $2,750

(2) Mr Froome, the manager of another racing team, approaches Bike Racers Co after Mr Wiggo. He offers to wait until the first two bikes are sold to Mr Wiggo and to then order the third and fourth bikes to be produced.

What would be the average price per bike charged to Mr Froome?

A $2,064

B $2,280

C $2,640

D $4,128

(3) The manager of a third racing team, Mr Hoy, approaches Bike Racers Co shortly after Mr Froome. He offers to immediately equip his entire team of eight racers with the new bikes, before a sale is made to anyone else.

What would be the price per bike if Mr Hoy placed an order for the first eight bikes, to the nearest $?

A $2,048

B $2,122

C $3,000

D $4,128

(4) The first phase of production has now been completed for the new bike. The first bike actually took 45 hours to make, and the total time for the first eight bikes amounted to 151.875 hours, at which point the learning effect came to an end.

What was the actual rate of learning which occurred?

A 72.5%

B 75%

C 82%

D 85%

(5) **Which of the following statements on the presence of a learning curve are NOT correct?**

(1) A standard costing system would need to set standard labour times after the learning curve has reached a steady state.

(2) Identification of the learning curve will permit the company to better plan its marketing, work scheduling, recruitment and material acquisition activities.

(3) Careful and accurate budgeting will ensure the learning curve effects are favourably impacting on labour costs.

(4) Accurate and appropriate learning curve data are easy to estimate.

A Statements (1) and (2)

B Statements (2) and (3)

C Statements (1) and (4)

D Statements (3) and (4)

7 Other quantitative analysis techniques

Businesses may also want to quantify forecasts for budgeting, planning and evaluation purposes. There are a number of quantitative techniques students should be familiar with, such as correlation, linear regression and time series analysis.

In exam scenarios, students must be able to explain and apply those techniques. They also must be able to discuss the suitability, principles, uses and limitations of these techniques.

Linear regression

The high-low method only takes account of two observations – the highest and the lowest. To take account of all observations, a more advanced calculation is needed. It is known as **linear regression,** and uses a formula to estimate the linear relationship between the variables.

Linear regression is a simple statistical tool used to model the dependence of a variable (say, costs) on one (or more) variables (say, volume). This functional relationship may then be formally stated as an equation, with associated statistical values that describe how well this equation fits the data.

Linear regression equation

The equation of a straight line is:

$y = a + bx$

where y = dependent variable

a = intercept (on y-axis)

b = gradient of straight line

x = independent variable

and $$b = \frac{n\sum xy - \sum x\sum y}{n\sum x^2 - (\sum x)^2}$$

where n = number of pairs of data

and $a = \bar{y} - b\bar{x}$

where $\bar{y}$ = average (mean) of y = $\Sigma y/n$

$\bar{x}$ = average (mean) of x = $\Sigma x/n$

Note: The above equations are provided in the formula sheet for this exam.

Regression analysis is a technique for estimating the line of best fit, given a series of data. It is essentially a statistical technique, based on the concept of 'drawing the line that minimises the sum of the squares of the deviations of the line from the observed data' (so it is sometimes referred to as the ‘least squares’ method). The regression line of y on x is used when an estimate of y (the **dependent** variable) is required for a given value of x (the **independent** variable).

Linear regression analysis can be used to make forecasts or estimates whenever a linear relationship is assumed between two variables, and historical data is available for analysis. Two such relationships are:

- **A time series and trend line.** Linear regression analysis is an alternative to calculating moving averages to establish a trend line from a time series. (Time series is explained later in this chapter). The independent variable (x) in a time series is time. The dependent variable (y) is **sales**, **production volume** or **cost**.
- **Total costs, where costs consist of a combination of fixed costs and variable costs** (for example, total overheads, or a semi-variable cost item). Linear regression analysis is an alternative to using the high-low method of cost behaviour analysis. It should be more accurate than the high-low method, because it is based on more items of historical data, not just a ‘high’ and a ‘low’ value. In this case:
  – The independent variable (x) in total cost analysis is the volume of activity.

- The dependent variable (y) is total cost.
- The value of a is the amount of fixed costs.
- The value of b is the variable cost per unit of activity.

When a linear relationship is identified and quantified using linear regression analysis, values for 'a' and 'b' are obtained, and these can be used to make a forecast for the budget. For example, a sales budget or forecast can be prepared, or total costs (or total overhead costs) can be estimated, for the budgeted level of activity.

e.g

Illustration 1 – Linear regression

X Co is forecasting its sales for the four quarters of 20X5. It has carried out a linear regression exercise on its past sales data and established the following:

$a = 20$

$b = 0.7$

The equation of the regression line is therefore:

$y = 20 + 0.7x$

When x is number of the quarter and y is the sales value in $000s. Calculate the sales for each of the quarters in 20X5.

Solution

		$000
Quarter 1	$y = 20 + (0.7 \times 1) =$	20.7
Quarter 2	$y = 20 + (0.7 \times 2) =$	21.4
Quarter 3	$y = 20 + (0.7 \times 3) =$	22.1
Quarter 4	$y = 20 + (0.7 \times 4) =$	22.8

Regression analysis is based on sample data. If we selected a different sample, it is probable that a different regression line would be constructed. For this reason, regression analysis is most suited to conditions where there is a relatively stable relationship between the variables.

Illustration 2 – Marcus Aurelius

Marcus Aurelius is a small supermarket chain that has 6 shops. Each shop advertises in their local newspapers and the marketing director is interested in the relationship between the amount that they spend on advertising and the sales revenue that they achieve. She has collated the following information for the 6 shops for the previous year:

Shop	Advertising expenditure $000	Sales revenue $000
1	80	730
2	60	610
3	120	880
4	90	750
5	70	650
6	30	430

She has further performed some calculations for a linear regression calculation as follows:

- the sum of the advertising expenditure (x) column is 450
- the sum of the sales revenue (y) column is 4,050
- when the two columns are multiplied together and summed (xy) the total is 326,500
- when the advertising expenditure is squared (x^2) and summed, the total is 38,300, and
- when the sales revenue is squared (y^2) and summed, the total is 2,849,300.

Calculate the line of best fit using regression analysis:

Advertising expenditure $000 **x**	**Sales** $000 **y**	**xy**	**x^2**	**y^2**
80	730	58,400	6,400	532,900
60	610	36,600	3,600	372,100
120	880	105,600	14,400	774,400
90	750	67,500	8,100	562,500
70	650	45,500	4,900	422,500
30	430	12,900	900	184,900
450	**4,050**	**326,500**	**38,300**	**2,849,300**

$$b = \frac{n\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2}$$

$$= \frac{6 \times 326{,}500 - 450 \times 4{,}050}{6 \times 38{,}300 - 450^2}$$

$$= \frac{136{,}500}{27{,}300} = 5$$

$$a = \overline{y} - b\overline{x}$$

$$a = \frac{4{,}050}{6} - 5 \times \frac{450}{6} = 300$$

The regression equation is $y = 300 + 5x$

Mathematical interpretation

If x = 0, then y = 300 and then each time x increases by 1 y increases by 5.

Business interpretation

If no money is spent on advertising then sales would still be $300,000. Then for every additional $1 increase in advertising sales, revenue would increase by $5.

Forecasting

The regression equation can be used for predicting values of y from a given x value.

Interpolation and extrapolation

(1) If the value of x is within the range of our original data, the prediction is known as Interpolation.

(2) If the value of x is outside the range of our original data, the prediction is known as **extrapolation**.

In general, interpolation is much safer than extrapolation.

Test your understanding 11 – Marcus Aurelius, continued

Marcus Aurelius has just taken on 2 new stores in the same area. The predicted advertising expenditure is expected to be $150,000 for one store and $50,000 for the other.

(a) Calculate the predicted sales revenues.

(b) Explain the reliability of the forecasts.

Limitations of simple linear regression

(1) **Assumes a linear relationship** between the variables.

(2) Only measures the relationship between **two variables**. In reality, the dependent variable is affected by many independent variables.

(3) Only interpolated forecasts tend to be reliable. The equation **should not be used for extrapolation**.

(4) Regression assumes that **the historical behaviour of the data continues into the foreseeable future**. One of the problems of both techniques (linear regression, as well as time series), is that forecasts are based on past data. Sudden changes in the market will not be immediately reflected in the forecasts. Thus there may still be a role for the managers to use their experience, intuition, and judgement to amend the forecasts produced by the statistical analysis.

(5) Interpolated predictions are **only reliable if there is a significant correlation** between the data.

(6) The accuracy of forecasting is affected by the need to adjust historical data and future forecasts to allow for price or cost **inflation**. When historical data is used to calculate a trend line or line of best fit, it should ideally be adjusted to the same index level for prices or costs. If the actual cost or revenue data is used, without adjustments for inflation, the resulting line of best fit will include the inflationary differences.

When a forecast is made from a line of best fit, an adjustment to the forecast should be made for anticipated inflation in the forecast period.

Illustration 3 – BW

Production overhead costs at company BW are assumed to vary with the number of machine hours worked. A line of best fit, based on 20X4 prices, will be calculated from the following historical data, with costs adjusted to allow for cost inflation over time.

Year	Total production overheads $	Number of machine hours	Cost index
20X1	143,040	3,000	192
20X2	156,000	3,200	200
20X3	152,320	2,700	224
20X4	172,000	3,000	235

Required:

(a) Reconcile the cost data to a common price level, to remove differences caused by inflation.

(b) If the line of best fit, based on current (20X4) prices, is calculated as:

y = 33,000 + 47x, where y = total production overhead costs in $ and x = the number of machine hours:

calculate the expected total overhead costs in 20X5 if expected production activity is 3,100 machine hours and the expected cost index is 250.

Solution

(a) As the line of best fit is based on 20X4 prices, use this as the common price level. Costs should therefore be adjusted by a factor:

$$\frac{\text{Index level to which costs will be adjusted}}{\text{Actual index level of costs}}$$

Year	Actual overheads $	Cost index	Adjustment factor	Costs at 20X4 price level $
20X1	143,040	192	× 235/192	175,075
20X2	156,000	200	× 235/200	183,300
20X3	152,320	224	× 235/224	159,800
20X4	172,000	235	× 235/235	172,000

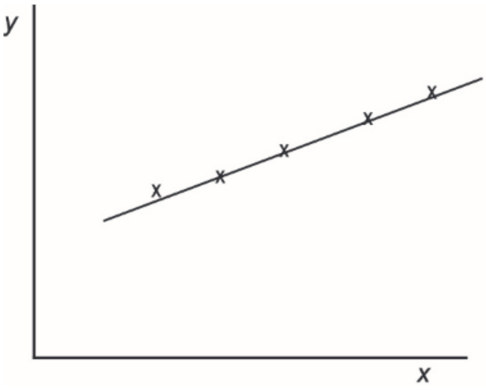
(b) If the forecast number of machine hours is 3,100 and the cost index is 250:

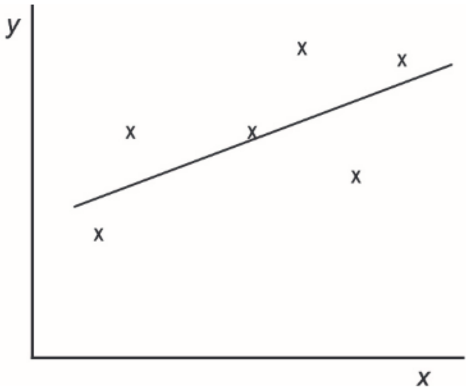
Forecast overhead costs = [$33,000 + ($47 × 3,100 hours)] × (250/235)

= $178,700 × (250/235) = $190,106

Correlation

Regression analysis attempts to find the relationship between a number of variables. Correlation is concerned with establishing how strong the relationship is.





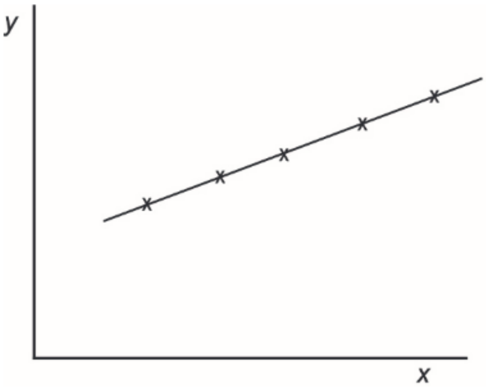
Clearly in the first diagram, the regression line would be a much more useful predictor than the regression line in the second diagram.

In terms of degrees of correlation, two variables might be perfectly correlated, partly correlated, or uncorrelated.

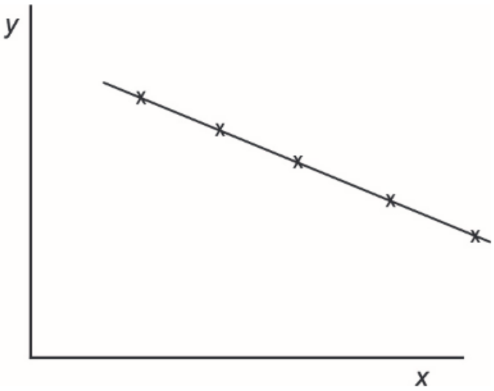
Different types of correlation explained

Perfect correlation

Positive correlation



Negative correlation



All the pairs of values lie on a straight line. There is an exact relationship between the two variables.